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ESSAYS
ON
SEVERAL PARTS
OF THE
Animal Oeconomy.

By *JAMES KEILL*, M. D.

Profecto verisimile est, & Hippocratem *&* Erasistratum, *& quicunque alii, non contenti Febres & Ulcera agitare, rerum quoque naturam ex aliqua parte scrutati sunt, non ideo quidem Medicos fuisse, verum ideo quoque majores Medicos exstitisse.* Cels. *in* Praef.

The FOURTH EDITION.

To which is added,

A Dissertation concerning the Force of the Heart, by *James Jurin*, M. D. F. R. S. with Dr *Keill*'s Answer, and Dr *Jurin*'s Reply.

ALSO

Medicina Statica Britannica, or *Statical Observations*, made in *England*, by *James Keill*, M. D. Explained and compared with the Aphorisms of *Sanctorius*, by *John Quincy*, M. D.

LONDON:

Printed for GEORGE STRAHAN, at the *Golden Ball*, against the *Royal Exchange*. 1738.

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TO THE

READER.

THE great Reputation, which the following Treatises have justly obtained in the learned World, makes it unnecessary to say any thing here in Commendation of them. It may be convenient however, to give the Reader some account of the former Editions of this Work; and of what Additions are made in the present Volume.

The first time of it's Appearance was in 1708, *under the Title of* An Account of Animal Secretion, the

Quantity of Blood in the Human Body, and Muſcular Motion. *In 1717, the Author publiſhed a ſecond Edition, corrected and enlarged, under the Title of* Eſſays on ſeveral Parts of the Animal Oeconomy. *In this volume were contained the five Eſſays, which are reprinted in the preſent Edition. The following Year, 1718, that Foreigners might enjoy the Benefit of theſe excellent Treatiſes, the learned Author was pleaſed to publiſh a third Edition in* Latin, *under the Title of* Tentamina Medico-Phyſica, ad quaſdam Quæſtiones, quæ Oeconomiam Animalem ſpectant, accommodata. Quibus acceſſit Medicina Statica Britannica.

Soon after the Appearance of this Edition, the learned and ingenious Dr Jurin *was pleaſed to write a Diſſertation on the Subject of our Author's third Eſſay, wherein he oppoſes what is there ſaid concerning the Force of the Heart: to this Diſ-*

ſertation

ſertation Dr Keill *wrote an Anſwer, and Dr* Jurin *replied; when Dr* Keill's *unhappy Death put an end to the Controverſy. This Diſpute was carried on with ſuch Candour, as well as Learning, as became the Gentlemen engaged in it. Their Papers were written in* Latin, *and printed in the* Philoſophical Tranſactions. *We have now tranſlated them into* Engliſh, *and added them after the third Eſſay, in this Edition.*

Dr Quincy, *having occaſion to Reprint his Tranſlation of* Sanctorius, *thought fit to add the Aphoriſms contained in our Author's* Medicina Statica Britannica, *to which he ſubjoined ſome Explanations of his own; which we have here taken the Liberty to inſert, not without ſome Remarks; for that haſty Writer did not give himſelf time to read the Aphoriſms, with the Attention, which they demanded. He left out alſo the*

Tables and Obſervations, from which thoſe Aphoriſms were drawn. We have here given an entire Tranſlation of the whole Piece, and of the two Diſquiſitions annexed; the Subject of the firſt of which is that, Obſtructed Perſpiration is not the cauſe of catching Cold; *the ſecond is on the* Attracting Power of an Animated Body.

THE

THE

AUTHOR's

PREFACE.

AS all Diseases whatsoever, which are incident to Human Bodies, are in reality nothing else than Disorders of the *Animal Oeconomy*; the Quantity and Quality of which are more or less clearly understood, in Proportion to the Knowledge of the *Oeconomy* itself; whatsoever can explain it, must also add light to the occult Natures of Diseases, establish the Practice of Physic upon a surer Foundation, and enable Physicians to make truer and more certain Judgments in most Cases.

That the Animal Body is a pure Machine, and that all it's Actions, whether those by which it perceives external Objects, or those by which it enjoys an internal Vigour, and good State of Health, depend entirely on Mechanic Causes, has now been long Universally allowed. The artificial and elegant Structure of the Eyes, and the great fitness of their Parts, for the offices of Vision, are illustrated by the Laws of *Opticks.* The wonderful Structure of the Muscles, the incredible Force which they exert in moving the Joints; and the different Junctures of the Bones, as well those which are slippery and exceedingly moveable, as those which are fixt, both of them being firm, and exactly fitted for Progression, and every Motion of the Members, were first Geometrically explained by *Borelli.* But since the most sagacious *Harvey,* (whose Praises the *British* Physicians

can

can never ſufficiently ſet forth) has demonſtrated, that the Blood circulates; and, by it's continual Circulation, gives both Senſe and Motion, both Health and Life to the Body, and Power to all the Parts to perform their Offices, ſo much Underſtanding, ſo much Wiſdom is every where ſeen, that there is not any action of the Parts, which cannot bear the ſevereſt Examination by the Laws of Mechanicks; nay, there is none, of which the Contrivance is not ſo excellent as to ſhew thoſe very Laws not ſufficiently accurate. The preſent Age is, and the ſucceeding Age will be highly indebted to *Bellini*, for inventing many Propoſitions concerning the Motion of the Blood, and it's unequal Swiftneſs, no leſs pleaſant than uſeful. Nor does Dr *Pitcairne* deſerve leſs Praiſe, who has explained the Mechanical Structure of the Lungs; who has unfolded the Cauſes of the

different Paſſages of the Blood, thro' the Heart of the Fœtus; the neceſſity of breathing after Birth; and how ſome of the Ante-natalitial Ducts are expanded, and others ſtopped by breathing. He has likewiſe demonſtratively explained the Symptoms of the Diſeaſes of the Eyes, and demonſtrated the Orifices of all the Glands to be circular. The moſt learned Dr *Freind* has writ in a Mechanical Way upon the Menſes: and no leſs have Dr *Mead* and Dr *Cheyne* deſerved of the learned World; of whom the latter has treated of Fevers; and the former of Poiſons, and of the Power of the Sun and Moon over Human Bodies. All of them have handled theſe Subjects more rationally, than ever any did before them, or perhaps any will hereafter. Theſe Sheets endeavour to follow the learned Labours of thoſe great Men at their proper Diſtance, and contain a Calculation

of

of the Quantity and Velocity of the Blood, of the Force of the Heart in driving the Blood thro' the whole Body, and of the Air upon the Blood in breathing; and if this is rightly performed, the unknown Uſe of the Spleen, and the obſcure Office of the *Vena Porta*, and the difficult manner of Secretion will no longer remain a Reproach to Phyſicians, who ſearch into Nature. There are many other *Phœnomena* of the *Animal Oeconomy*; which the Ages paſt thought inexplicable, which have now by ſeveral been made the Subjects of Geometrical Demonſtration; and if there were ſufficient *Data*, as they are called, I do not doubt but thoſe *Phœnomena*, which now torture the Brains of Philoſophers, would be clear to all. For if ſome Things, which to former Ages have appeared unaccountable, are clear to the preſent Age, why ſhould not our Poſterity, hap-

pier

pier than our ſelves, and ſtudious of the good of Mankind, and their own Reputation, diſcover the Things which have been long earneſtly ſought after by the Learned, and are ſtill involved in Darkneſs? This is by no means to be deſpaired of, if we conſider the Progreſs that has already been made, notwithſtanding the Mechanical Philoſophy, as applied to Phyſic, is ſtill in it's Infancy.

Now ſince the Animal Body is known to be a pure Machine, and all it's Actions from which Life and Health do flow, are the neceſſary Conſequences of it's Oeconomy; it neceſſarily follows, that all Diſeaſes ariſe from the Alteration of this Oeconomy. And they do as neceſſarily flow from this Change, as the Actions by which Life and Health are continued, did flow from the Oeconomy before the Change. If a Pendulum of ſuch a Length makes a Clock

a Clock to go exactly true, does not the Alteration of the Pendulum as neceſſarily cauſe it to go too faſt or too ſlow? And when all the reſt of the Movements are known to be in good Order, does not the quick or ſlow Motion of the Clock, as neceſſarily ſhew the fault of the Pendulum? It is the ſame thing in the Animal Body, for the ſame reaſoning holds good in that, as well as in other Machines, for the ſame Structure muſt always neceſſarily produce the ſame Effects; nor is the Caſe in the leaſt altered, that we have a Principle within us that is the cauſe of Motion, and yet is not itſelf ſubject to the Laws of Motion; for our Souls are not at all conſcious of the inward Motions of the Body, upon which Life and Health depend; and tho' it does excite Motions which diſturb the *Oeconomy*, and by which it miſerably torments itſelf, yet we know how to rectify theſe Irregula-

rities without any Regard had to the Soul; in the ſame manner exactly, as any one ſtrikes back a Ball ſent from another's Hand, with a Force oppoſed to the Ball, not to the Hand that moves it. But I do not argue thus from an Opinion, that all Diſeaſes may be cured if the Cauſe is unknown, or which is the ſame thing, if the Cauſe is neglected; for the ſmaller Impulſes of the Mind may be withſtood, ſeeing Time leſſens even the diſturbance of the Mind; but Diſeaſes which proceed from a Cauſe continually operating, cannot be extinguiſhed, till that Cauſe is taken away. From which it is plain, that the Knowledge of the Animal Oeconomy is highly neceſſary for the underſtanding the Natures of Diſeaſes, and that the greater our Knowledge of that is, the better the Nature of Diſeaſes muſt be known.

It

It must indeed be confessed that this Method of improving the Art of Physic is very difficult, and full of Labour, and Observation, and Judgment; but all the Investigations of Nature, are mostly surrounded with Difficulties; and there is hardly any thing excellent, or useful to Mankind, that is not difficult; and to be weary of enquiring is very shameful, when what is sought after is Noble and Useful. It has pleased the great Author of Nature, that the Understanding of Men should be exercised with such Things; and as Things cannot otherwise be treated, than their Natures admit, we must proceed this Way, if we would have any Success in curing Diseases; for Nature knows no other Method.

There were formerly some Physicians, nor are there wanting even since the Improvement of Physic by Philosophy, some who think that

the Art of curing Diſeaſes is only to be promoted by Experiments, by obſerving what Things are hurtful, what beneficial in each Diſeaſe; and that the Study of the hidden Natures of Things is altogether ſuperfluous, and of as little uſe to a Phyſician, as it would be to a Sailor to know the reaſon of the Flux and Reflux of the Sea, or the wonderful Theory of the Loadſtone. But if we diligently conſider the number of Diſeaſes, their different Species, different Appearances, according to the almoſt infinite Variety of the Conſtitutions of our Bodies, and the Air in which we live: If we reflect likewiſe on their various Complications, on the almoſt infinite Variety of Medicines, and the critical Times of uſing ſometimes one, and ſometimes another, and even ſometimes of abſtaining from them altogether, we may as well expect that a blind Man ſhould ſhoot Flying, or one

that is Deaf tune an Organ, as that a Phyſician led only by that blind Guide Experience, ſhould cure Diſeaſes; and whoſoever judges otherwiſe, muſt either not have conſidered theſe Things, or not ſufficiently have attended to them. I am not Ignorant, that the Art of Curing, did indeed at firſt riſe from Experiments, when Men wholly unacquainted with Science, were driven by their ill Health to make Trial of any Thing. But this Infant Age of Experience made but little Progreſs in the Cure of Diſeaſes; for there is no Acceſs even to Experiments, but by ſome Knowledge in the Animal Oeconomy; ſo that the firſt State of Phyſic contained but a few Obſervations, and thoſe were general, and not far removed from common Senſe and Cuſtom, and might eaſily be collected by any one, who diligently obſerved himſelf. There are ſome indeed who inge-

nuoufly confefs, that a general Knowledge of the Body and it's Oeconomy may be of fome little Service to thofe who ftudy Phyfic; but that the nicer inquiries into the Structures of the Parts, and the *Minutiæ* of the Veffels and Nerves, and the different Offices, to which each are deftined by Nature, are altogether ufelefs, and of no more Confequence to a Phyfician than to a Painter: But how trifling is this! as if a lame and imperfect Knowledge went as far in the Cure of Difeafes, as the fame in it's utmoft Perfection, who would not be concerned at fo unhappy a Fate of Phyfic? For no Man would Reafon thus even in the loweft Art. If any one fhould confidently affirm, that he could guide a Ship from *Britain* to any Port of the *Eaft Indies*, which, as he had been informed, lay between the Eaft and the South, better than if he knew the Longitude and Latitude of it exactly;

would not all Men despise his Ignorance and Impudence? But with what success are Things of this Class boasted of by Quacks, I wish I could not say by Men otherwise of good Learning, and from whom we might expect better? By whom every attempt to promote Physic by right Reason, is treated as vain and useless, to the great Detriment of Learning. A general Knowledge of the Animal Oeconomy, may inform us of the Indications that are common to all Diseases, but not of those which are proper to each. Surely it behoves a Physician not only to know some common Things, but also the Nature and Quality of what he is to contend with; in what Part it resides, and the Quantity and Quality of the Force with which he is to remove it. He who is ignorant of this, will collect his whole Forces against a weak Enemy, that would easily yield to a

ſkillful Aſſailant, and applies them at Random, without knowing where to make his Aſſault; being ſure to cauſe a Confuſion, and not ſure of relieving Nature. But they, ſay they, reject the Knowledge of the Animal Oeconomy, becauſe there is nothing certain in this Science beſide ſome Generals; that Nature is incomprehenſible; and that the Explications which the moſt Ingenious have made of the Animal Oeconomy, are mere Figments of the Brain, and as there exiſt no Footſteps of them in Nature, that they can give no Light into the Cure of Diſeaſes. This ſort of Diſcourſe is the Refuge of Idleneſs and Ignorance. For if *Euclid* and *Archimedes* had judged that Nature was inexplicable, (and this might have been ſaid with more Reaſon formerly than now) thoſe great Men would certainly have ſaved themſelves the Trouble of drawing up the Elements of Geo-

metry,

metry, nor would Sir *Iſaac Newton*, after ſo many Ages, have inveſtigated the Laws by which the Celeſtial Bodies are carried round in their Revolutions. The *Empiricks* might aſk, what do theſe Geometricians mean by ſuch a heap of Speculations? Do they think the beautiful Order of the World can be explained by Schemes formed out of their Brains? In which we can never diſcover by any Reaſoning, with what Wiſdom every Part is conducted; Vain and ridiculous! Surely ſuch as aim at this, had need behold the Heavens, and obſerve the Orders of the Stars, the immutable Courſes, the Riſings and Settings, the accelerated and retarded Motions, the anniverſary Viciſſitudes of the Sun, and the various Changes of the encreaſing and decreaſing Moon. Nature offers herſelf to thoſe who proceed this way, which ſhe herſelf points out, whilſt ſhe

will not ſuffer herſelf to be taken by Nets ſpun out of the Brain. This is talking plauſibly; but how lame and weak Aſtronomy had been without being ſupported by Geometry, is known to every Body. Now the Phyſician receives no leſs Aſſiſtance from the Animal Oeconomy, than the Aſtronomer does from Geometry: without the Knowledge of theſe, neither of them can reduce his Obſervations and Experiments into Uſe. That Knowledge which confines itſelf to Experiments alone, does, and always will, lie on the Ground, but that which laying it's Foundation on them, builds itſelf up by right Reaſoning, will at laſt reach to the top.

I do not pretend, that the Explications of the Animal Oeconomy are equally certain and clear with the Propoſitions of Geometry; I wiſh they were, and then their undoubted Uſefulneſs would leave no

room

room for Diſputing; but what I have ſaid was with an Intent, that Phyſicians being perſuaded of the abſolute Neceſſity of the Knowledge of the Animal Oeconomy, for the Knowledge of Diſeaſes, ſhould diligently labour with all their Power in cultivating it. Nor ought the Difficulty of the Work to deter any one, but the great Uſefulneſs of it, ſhould awake all ingenious Perſons, and ſtir them up to purſue it; a Science of the greateſt Uſe ought not to be rejected, becauſe there are abundance of things falſe in it, many only probable, and but very few evidently true. Nothing is invented and perfected at the ſame Time. All Arts and Sciences had their Infancy, in which were many things abſtruſe, few underſtood and known, and they grew by inſenſible Degrees, from a low Beginning to their greateſt Height. Truth does not ſpring out at once, like the

ſparks

ſparks out of a Flint, but like a hidden Treaſure, plentifully repays the unwearied Labours of thoſe who dig for her; one Place is to be ſearched after another, nor will that Man ever get Poſſeſſion of the Riches, who will not dig without a Certainty of diſcovering them. The Art of Politics is entirely conjectural, in which the moſt ſkilful Governors of the Commonwealth are often miſtaken; but is it therefore to be eſteemed no Art at all? That Phyſic alſo which depends upon Experience and Practice, has more uſeleſs, nay, new things, than uſeful ones; and yet this is retained by thoſe, who reject the Knowledge of the Animal Oeconomy for it's Uncertainty. And Men of no ſmall Learning, ſometimes fall into grievous Errors, who are converſant in Geometry, which truly boaſts of the Beauty of Certainty.

But

But tho' I would fain perſuade the Students of Phyſic, that the Knowledge of the Animal Oeconomy is highly neceſſary to be acquired, yet I do not deny but that Experiments have their Uſe. For from them all, natural Knowledge (of which this, which I propoſe to be cultivated, is no ſmall or ignoble Part) being derived, proceeds on ſure Ground; and as often as it begins to grow faint, ſtumble, and decline from the right Way, being animated, ſupported, and ſet right by new Experiments, it makes greater and better Progreſſes. The only way to the Knowledge of the Animal Oeconomy lies thro' Experiments and Obſervations, about the Structures of the Parts of the Body, and Nature of the Blood and Secretions. And whoſoever, neglecting theſe, endeavours to explain Nature, by Theories, and ingeniouſly contrived Hypotheſes, is only building Caſtles

Caſtles in the Air. I do not deny that the Art of Curing roſe at firſt from Experiments, and it cannot be denied that ſeveral good Remedies have been found out by Chance, or rather by Divine Appointment, as without Doubt, the uſe of the Bark was by the *Indians*; whom we may reaſonably ſuppoſe to have been ignorant of the Animal Oeconomy; but no Man can think this a good Method for improving of any Science; to build upon Experiments blindly made, without any formed Deſign. If indeed Experiments are directed, by a Knowledge in the Animal Oeconomy, ſomething may at length be hoped for from ſuch a Method; and the greater the Skill is, by which the Experiments are directed, the greater will be the Probability of Succeſs; becauſe by that, we can aim more directly and certainly at the Irregularities of the Oeconomy; and he that knows the

Diſeaſe

Diſeaſe is more likely to cure, than he that is wandring and dubious in his Mind, and uncertain what it is he ought to aim at. If he hits the Mark it is owing more to mere Chance, than any good Skill. The Theory indeed of any Art, which has already arrived at it's higheſt Perfection, how pleaſing ſoever it may be to a Philoſopher, may perhaps be of as little uſe to an Artificer, as that of the Tides and Loadſtone would be for ſailing in the Channel. But as theſe might be of great Uſe to a Sailor taken out of his Knowledge to an unknown Part of the World, ſo a Diſeaſe unknown to a Phyſician, is to be diſcovered and better explained by the Animal Oeconomy. The Art of Curing, is ſo far from being brought to Perfection, that there is no Diſeaſe, how ſlight ſoever it may generally appear, that will not ſometimes

deſpiſe

despise and elude all the Power of Medicine.

Tho' the Doctrine of the *Empiricks*, which despises all Reasoning, could never be set aside by Reasoning, yet that Method of curing Diseases which draws salutary Indications from evident Causes, has been always most approved by the best Physicians in all Ages. No one of these ever struck the Knowledge of these Causes, merely out of his own Brain, but judged that it was to be attained by a diligent Observation of Nature, and an accurate Animadversion and Comparison of all the Appearances in the several Stages of a Distemper. The first that excelled in this Way, was the Divine *Hippocrates*, who has thereby rendered his Name immortal. His accurate Delineations of Diseases are truly charming. He used to perceive and observe Nature when she was about any new Work,

Work, with ſo much Diligence and Circumſpection, that no ſudden Change of a Diſeaſe, no unuſual Period, no new Symptom could ariſe, without his obſerving it; which produced a ſurprizing Sagacity in judging of future Events. In this Method, ſome of the Antients have followed him, but none ever came ſo near to him, as the deſervedly renowned Dr *Sydenham*, and Dr *Morton*, whoſe accurate Hiſtories of Diſeaſes, for a full, exact, and nice Enumeration, of evident Cauſes, Signs and Symptoms, for a judicious diſtinguiſhing of the ſeveral Species of the ſame Diſeaſes, and for juſt Prognoſtics, founded upon a careful Obſervation of the common Effects of ſuch and ſuch Appearances, have ſurpaſſed all Hiſtories of the Modern Phyſicians.

This is that excellent Art, which added to a juſt Knowledge of the Animal Oeconomy, can only make a com-

a complete Phyſician. As one, however ſkilled in Geometry, cannot be called an Aſtronomer, unleſs he is acquainted with the Motions of the Heavenly Bodies, ſo neither can any one be called a Phyſician, who being verſed only in the Animal Oeconomy, is ignorant of the Hiſtories of Diſeaſes. And on the other ſide, as one Ignorant of Geometry can make but a wretched Aſtronomer, ſo he can make no better a Phyſician that has not laid a good Foundation of the Animal Oeconomy. If we conſider the Animal Body as a Machine, it's Diſeaſes, and all their Symptoms are only the irregular Motions of the Machine. Now ſuppoſe a Man ignorant of the Structure of a Clock or Watch, it is impoſſible he ſhould ever be able to put it in right Order, tho' he had never ſo exact an Hiſtory of it's irregular Motions. So a Phyſician, ignorant of the Animal Oeconomy,

Oeconomy, is ignorant of the Structure of the Machine he undertakes to regulate, and the beſt and exacteſt Hiſtories of Diſeaſes can never ſuggeſt to him any Indication of Cure.

Give me leave to illuſtrate this by an Example or two. The Symptoms that accompany the Jaundice, are ſo explained by the Animal Oeconomy, that there is no room to doubt, but that this Diſeaſe ariſes from an Obſtruction of the Liver; whence Bleeding, Vomiting, Purging, and Deobſtruent Medicines, which are uſed in curing of this Diſeaſe, are plainly indicated; but tho' the Hiſtory of this Diſeaſe is known ſo accurately, that nothing farther is wanting in that Way; yet becauſe the Animal Oeconomy does not diſcover the Nature of the obſtructing Humour, therefore it is not certainly known what ſort of aperient and reſolving Medicines

are in ſome Caſes proper; for different Subſtances require different Reſolvents, as every one that is acquainted in Pharmacy and Chymiſtry knows. The Jaundice therefore being explained by the Animal Oeconomy, requires the Uſe of deobſtruent and reſolving Medicines; but what are the moſt proper Medicines of this kind we know not, becauſe we are ignorant of the Nature of the Obſtruction. Our Indications therefore are true and juſt, ſo far as the Knowledge of the Animal Oeconomy reaches; but where that leaves us, we only grope in the dark, and find out Remedies by Chance.

The preceding Example ſhews how the Method of curing is found out by the Help of the Animal Oeconomy; now let us ſee what the Hiſtory of Diſeaſes can do without it. The firſt that offers itſelf, is a *Tertian Fever*, which, in it's right Shape,

Shape, is at firſt known by every Quack; and with all it's various and counterfeit Appearances, cannot deceive any Phyſician; of ſo peculiar a Nature it is, that whatſoever Maſk it puts on, under the Shape of whatſoever Diſeaſe it conceals itſelf, and various ſurely are it's Appearances, it is eaſily perceived by a quick Eye, and cannot be hid. But ſo certain a Knowledge of the Diſeaſe, and of every thing that belongs to the Diſeaſe, becauſe the Nature of the Blood, which is the Seat of the Diſtemper, is ſtill involved with the thickeſt Darkneſs, cannot help us to any Indication, which, if anſwered, will work a Cure. Therefore, either the Animal Oeconomy muſt be acknowledged to be neceſſary to a Phyſician, or all the Hiſtory of Diſeaſes muſt together with it be rejected and contemned, and if both are to be rejected, I do not ſee the Dif-

ference between a learned and ingenuous Physician, and an ignorant and lying Quack; for when this is taken away, Learning must be accounted useless and perish. Nor would there be any Occasion to instruct Youth in the *Universities* in the Knowledge of Diseases, and the Explication of Nature, but their Time ought to be taken up in collecting *Receipts*, wheresoever they could meet with them. We owe the Remedy for Intermitting Fevers to the barbarous and ignorant *Indians*, being ourselves no better skilled in this Part of the Oeconomy than they; but even from this, tho' the *Empiricks* boast so much of it, and not without Reason, it clearly appears how vain their Art is; for tho' a more noble Specific than the Bark was never known, yet we are frequently forced, when Intermitting Fevers are complicated, to call in to our Assistance the

Knowledge of the Animal Oeconomy; and by Bleeding, Vomiting, Purging, and other proper means, to render that Specific uſeful, which before was of no Effect.

If the Animal Oeconomy were perfectly underſtood, and the Hiſtories of Diſeaſes exactly known, the right Method of curing each Diſeaſe, might be evidently and certainly deduced. And therefore, when a Diſeaſe is exactly known, if the right Method of curing it cannot be deduced, it muſt be becauſe the Animal Oeconomy is not ſufficiently underſtood. And from hence it follows, that the larger and clearer Knowledge any one has of the Animal Oeconomy, the more probable and certain Indications of curing, will he be able to deduce.

The Animal Oeconomy is it ſelf no inconſiderable Part of Natural Philoſophy; and our Bodies are ſo ſtrongly influenced by Variety of Diets, and ſo many things from without, that indeed the whole Study of Nature ſeems to be uſeful to him that would underſtand it. And every Diſcovery in things that affect us, ſeems to be an Improvement of Phyſic. Some of the Antients have indeed left us very judicious and accurate Hiſtories of Diſeaſes; but ſince the Diſcovery of the Circulation of the Blood, and the late Improvement of Natural Philoſophy; our Reaſonings upon theſe Hiſtories, in order to find out the Seat and Nature of the Diſtemper, and from them to deduce a right Method of curing, and the whole Practice of Phyſic, by an accurate Inquiry into the Natures and Seats of Diſeaſes, by a more juſt and conciſe Method of

of Cure, and by the Diſcovery of many Remedies, is greatly refined and improved.

But notwithſtanding the great Advantages Phyſic has received from Natural Philoſophy; it muſt be owned, that it has received no ſmall Detriment from a wrong, and too common Method of philoſophizing; that is, by laying down of Principles, not drawn from the *Phænomena* of Nature, but uncertain Fictions of the Brain; ſuch as are the firſt and ſecond Elements of *Des Cartes*, which have no Foundation in Nature, but are purely chimerical; and yet their whole natural Philoſophy depends upon them. If their reaſoning upon ſuch fictitious Principles were juſt, we could admit it only as barely poſſible, not as true, or ſo much as probable. Nor could we give our Aſſent to it, till it was proved by the

most strong, most weighty, and most certain Arguments, that such Principles do really exist in Nature, which is impossible to be done. Most Theories of Diseases are built upon such Principles, and therefore we never can have any Certainty, or indeed so much as a Degree of Probability, that the Indications drawn from them are right, or such as, if answered, would cure the Disease. If a Man may suppose any Principles which are not evidently false, he may at the too common loose way of Reasoning, give a thousand Solutions of the Nature of every Distemper, all equally true, and all indicating different Methods of curing, and perhaps none at all. Tho' fine Hypotheses supported by slight Reasonings, artfully built up, and elegantly adorned, may please the Fancy, and delight the Curiosity of a Philosopher, yet they can be

no Relief to a Body afflicted with Diseases or Pain.

It is unlawful to hazard Mens Lives upon *elegant* Reasonings, but to save our Neighbours upon such as are *solid*, is noble and praiseworthy. He that trusts to an Hypothesis which is barely probable, runs just such a Risque of his Life, as he does of his Money, who puts into a Lottery, where there is only one Chance of his getting his Money again without Interest, but many of his being an entire Loser.

But this Sort of Philosophy is not only useless, but prejudicial also to Physic. For Physicians that are fond of the Productions of their own Brains, are apt to neglect the Operations of Nature; framing Diseases to their Opinions, rather than Opinions according to Diseases. And from hence it comes to pass, that most of the late Explications of Diseases are only Philosophical Romances,

mances, and contain nothing of that diligent Obſervation of Nature, which gained *Hippocrates* immortal Honour, and without which it is impoſſible, that ever the Art of Phyſic ſhould be improved, and arrive to Perfection.

But ſuch is the Narrowneſs of the Human Intellect, that few Men are fitted for various Studies, or even for the ſeveral Parts of the ſame Science. Many have been very nice and exact in making Aſtronomical Obſervations, that have had but a very moderate Skill in Geometry, and ſuch as have excelled in Geometry, have often been deficient in Aſtronomy. And Men either from a want of Integrity, and a Senſe of that Truth and Juſtice that is due to Mankind, or from a natural Fondneſs of their own Qualifications, and an Unwillingneſs to think any thing of which they are ignorant, neceſſary to the Science they profeſs, have generally

generally recommended and extolled thoſe Parts which they beſt underſtood themſelves, but bantered and decryed thoſe they were leſs ſkilled in, tho' not leſs neceſſary and uſeful. Natural Philoſophy and the Hiſtories of Diſeaſes muſt go hand in hand in the improving the Art of Curing; it is not poſſible to make any uſe of the laſt, without the Knowledge of the firſt. And I may venture to ſay, that there is no Man that practiſes, but who does it upon ſome Knowledge of the Animal Oeconomy, or ſome notions of his own, which are more or leſs clear according to his Skill in Natural Philoſophy. And for the Truth of this, I appeal to Dr *Sydenham*'s own Writings, who by his philoſophizing, has evidently ſhewn us the Neceſſity of that Science, he ſo much decried, and ſo little underſtood. He was undoubtedly a great Man, and the World will always be obliged

obliged to him for his accurate Hiſtories of Diſeaſes; but there is no Man without Errors, and where one of his deſerved Character falls into a Miſtake, it does a great deal more hurt, than if hundreds of others of leſſer Note had been guilty of the ſame.

The following Treatiſes contain a few Thoughts about ſome of the principal Parts of the Animal Oeconomy; it was the Conſideration of the Uſe of the *Vena Porta* which gave me the firſt hint to think, that the ſeveral Humours of the Body were formed by the Attraction of the Particles of the Blood; which, when I had communicated to my Brother, he was pleaſed to ſee his Theorems of Attraction illuſtrated by ſo eminent an Inſtance, and ſent me the Demonſtration of the third Propoſition.

The firſt that I know of, who, to explain Secretion, thought it neceſ-

ſary to conſider the State of the Blood at different diſtances from the Heart, was the ingenious Dr *Cockburn*; and tho' he was not then aware of this Principle of Attraction; yet he wiſely foreſaw that different Velocities of the Blood were requiſite for ſecerning of different Fluids.

As the Learned Dr *Gregory* has ſhewn us, in the Preface to his Aſtronomy, that the Gravitation of the Heavenly Bodies towards one another, was known to the Antient Philoſophers; ſo this Power by which the ſmall Particles of Matter attract one another, was the Doctrine of *Hippocrates*, (*a*) whoſe whole Philoſophy is built upon a certain *Propenſion* which ſome things have to one another, whereby they *attract*, *retain*, and *alter* one another. From whom I do not

(*a*) Vide Mr *Le Clerc*'s Hiſtoire de la Medicine.

greatly

greatly (*b*) differ in my Explication of the Power of Cathartic Medicines. *Galen* (*c*) does assert this Propension or Attraction, to be an universal Power in Matter, and (*d*) compares it to the Power, by which a Loadstone draws Iron. And in his Treatise *de Purgantium Medicamentorum Facultate*, does bitterly inveigh against all those, who in Opposition to *Hippocrates*, did assert, that all Purges, purged all Humours indifferently; and at last concludes with *Hippocrates*, that every purga-

(*b*) Τὸ γὰρ φάρμακον, ὁκόταν ἐσελθῇ ἐς τὸ σῶμα, πρῶτον μὲν ἄγει, ὃ ἂν αὐτέῳ κατὰ φύσιν μάλιστα ᾖ, τῶν ἐν τῷ σώματι ἐνεόντων· ἔπειτα δὲ καὶ τἄλλα ἕλκει τε καὶ καιθαίρει. De Natura Hominis.

(*c*) Καὶ σύμπνουν ὅλον ἐστὶ, καὶ σύῤῥουν τὸ σῶμα· καὶ ἡ φύσις ἅπαντα τεχνικῶς καὶ δικαίως πράττει, δυνάμεις ἔχουσα καθ' ἃς ἕκαστον τῶν μορίων, ἕλκει μὲν ἐφ' ἑαυτὸ τὸν οἰκεῖον ἑαυτῷ χυμόν. ἕλξαν δὲ περιφύει παντὶ τῷ μέρει τῷ ἐν αὐτῷ, καὶ τελέως ἐξομοιοῖ. Natur. Facult. *Lib. I. cap. xii.*

Δέδεικται γὰρ ἡμῖν, ἐν τοῖς περὶ φυσικῶν δυνάμεων ὑπομνήμασιν, ἡ μὲν φύσις ἑκάστου τῶν μορίων, τέτταρσι δυνάμεσι χρωμένη, ἑλκτικῇ τε τοῦ οἰκείου, καὶ καθεκτικῇ τοῦ αὐτοῦ. Galen. Commentar. in Hippocrat. Aphorism. *Lib. I.* 22.

(*d*) Ἐξεύρωμεν μὲν οὖν κοινῇ, πῶς ἕλκεται· πῶς δ' ἄλλως ἢ ὡς σίδηρος ὑπὸ τῆς Ἡρακλείας λίθου, δύναμιν ἐχούσης ἑλκτικὴν τοιαύτης ποιότητος. Ibid. II. 7.

tive

tive Medicine, draws to it's ſelf it's proper Humour. And in his ſecond Book *de Naturalibus Facultatibus*, he ſtrenuouſly maintains a *Vis Attractrix*, in Nature againſt *Epicurus*, *Aſclepiades*, *Eraſiſtratus*, and others. All which does ſufficiently ſhew, that this Attraction of the ſmall Particles of Matter, is no Innovation in Philoſophy, but was received of old by the Antients, and by them tranſmitted to us.

The Manner by which I do ſuppoſe the Glands do ſeparate the ſeveral Humours from the Blood, is much the ſame with that of Dr *Morland*'s, publiſhed in the Philoſophical Tranſactions. What I have ſaid in this Book, concerning the Quantity of Blood, is ſufficient to ſhew how little reaſon common Opinions are ſometimes grounded upon. And the Difficulty of the Subject, and the new Method of handling it, will, I hope, procure this ſhort Eſſay

a fa-

a favourable Reception. The Theory of Mufcular Motion does follow fo naturally and eafily from the Principle of Attraction, that one would be almoft tempted to believe it the genuine Method of Nature. The Determination of the *Vis Elaftica* was the Thought of the learned *John Bernouli*; but this way of demonftrating it, was communicated to me by my Brother: I am too fenfible of my own Inabilities, to imagine I have brought thefe things to Perfection. I fhall be fufficiently pleafed, if what I have here done fhall ftir up Men better qualified to make Difcoveries in Nature, or be any Affiftance to them.

Tho' any one with a moderate Skill in the Mathematics may underftand thefe Difcourfes, yet, without that, no one can judge of their Truth, and Ufefulnefs, in explaining the Animal Oeconomy.

ESSAYS
ON
SEVERAL PARTS
OF THE
Animal Oeconomy.

ESSAY I.

Of the Quantity of Blood in the Human Body.

I KNOW not upon what Grounds Phyficians and Anatomifts have generally determined the Quantity of Blood in the human Body, to be between fifteen and twenty-five pound Weight. All that I can find is the large Quantities of Blood voided by Perfons dying of violent *Hæmorrhagies*; fo that according to their feveral Obfervations, fome have afcribed a greater, and fome a fmaller Quantity of Blood to the Body. Dr *Moulin* has allotted by much a fmaller Quantity than any, and gives

How Dr Moulin *did determine it.*

gives us the Method by which he determin'd it in the *Philosophical Transactions.* He says, that in a Sheep, which alive weigh'd 118 ℔, he found by bleeding it to death, that it contain'd $5\frac{1}{4}$ ℔ of Blood, which is less than $\frac{1}{22}$ part of the Weight of the Sheep. That in a Lamb weighing $30\frac{1}{2}$ ℔ when living, there was but $1\frac{1}{2}$ ℔ of Blood, which is about $\frac{1}{20}$ part: Now upon the Supposition, that a Man's Blood bears the same Proportion to his Weight, as that of the Lamb's (which is the greatest) had to its Weight, it will follow that the Quantity of circulating Blood in a Man, weighing 160 ℔ will not exceed 8 ℔.

Neither of these ways just.

These Estimations (tho' widely different from one another) are both made from the Quantity of Blood voided at an open *Vessel*; and they are both founded upon this Supposition, that almost all the Blood in the Body runs out at the Wound; a Supposition I can by no means allow to be true, and which I shall evidently shew to be false. For suppose the right external *Iliack* Artery cut asunder, so as that the Blood may freely flow out of the Wound: How can the Blood which is in the right Leg below the Wound, be emptied? It is cut off from the rest of the Blood above, which should drive it forwards, and all the Assistance it can have from collateral *Branches*, which communicate with it can be but very little, because they themselves can receive but a very small quantity of Blood, the Blood running all to the Wound, where it finds the least Resistance. The Arteries in the Leg can beat no longer, because the Pulse depends upon the Quantity of Blood thrown into them every

Systole

Syſtole of the Heart, which in this Caſe is nothing; and theſe being the only regular Cauſes of the Motion of the Blood, the Blood muſt ſtagnate in the Crural Veſſels. All that can be ſaid is, that the great Arteries will once contract, and may perhaps have ſome ſmall Vibrations afterwards, by which they will thruſt the Blood into the capillary Veſſels, and their convulſive Motions will ſqueeze the Blood forwards in the Veins; but when an Animal once falls into Convulſions by bleeding, it can bleed but little afterwards, the Motion of the Heart ceaſing; beſides we know, that neither all Animals, nor all Parts of an Animal are convuls'd upon bleeding to death: and tho' the great Arteries may contract, yet this Contraction muſt be very languid in the ſmall Arteries, which being innumerable, the greateſt part of the Blood will be lodg'd in them, there being nothing to drive it out of their contorted Channels, but it muſt ſtill remain in them, as likewiſe in the Fibres of the Muſcles, which appear of a red Colour, only upon the Account of the Blood contain'd within them, their Subſtance being naturally white. Again, tho' the right and left Iliack Arteries do in the natural State receive an equal quantity of Blood; yet when a Wound is made in the Right, thro' which the Blood has an eaſy Paſſage, this muſt receive much the greateſt part of the Blood which comes down the Aorta, and conſequently the Circulation of the Blood muſt be very ſlow in the left Leg, and no more Blood can come from it, than what is thruſt out meerly by the Motion of the Body, or what flows naturally of it ſelf in the ſtrait

and large Veſſels, as Fluids will do to come to an *Equilibrium*; for the ſame Reaſon the aſcending Trunk or Branches of the *Aorta* can receive but a ſmall quantity of Blood, and therefore the Pulſe in the Arteries of the Brain muſt be very languid or none at all, upon which account the Motion of the Spirits muſt ceaſe, and conſequently that of the Heart. When the *Aorta* begins to be empty (which muſt quickly happen when the Blood runs out at a Wound of a large Artery) then the Blood having little or no Reſiſtance, will flow eaſily into the empty Veſſel, and a very ſmall Quantity of it will enter the Orifices of the Coronary Arteries of the Heart, the Valves covering them, and conſequently the Motion of the Heart muſt ceaſe for want of Blood.

The greateſt Effuſion of Blood not from the largeſt Veſſel.

It is for theſe two laſt Reaſons, that the larger the Veſſels are that are wounded, the ſooner the Animal dies; and if the *Aorta* it ſelf was cut aſunder, there would be a ſmaller Effuſion of Blood from it, than from a ſmaller Artery: For ſince it is the Blood in the *Aorta* that thruſts forward the Blood in the Veins, and makes it paſs from the *Vena Cava* into the right Auricle of the Heart; it is plain, that when the Blood in the Aorta is intercepted, the Blood will be no longer driven thro' the Veins, but will ſtagnate in them, no more of it coming to the Heart, than what by reaſon of the Fulneſs of the Veins flows into it, and conſequently the Heart throwing but a ſmall Quantity of it into the *Aorta*, the Circulation will be quickly ſtopt, both in the aſcending and deſcending Trunks, and there will be no greater Effuſion of Blood than what can be

contain'd in the great Artery which holds but little. Whereſoever the Wound is made, ſo long will the Animal live as the great Artery keeps full, but whenever that begins to empty, the Blood in all its Branches muſt ſtop, and conſequently the Animal muſt die.

The greateſt Flux of Blood from the ſmalleſt Veſſels.

The Veſſels of the Animal Body are not meer unactive Tubes; but as they may be gradually dilated, ſo they can gradually contract again; and as they cannot ſuffer any violent and ſudden Stretching without breaking, ſo neither can they immediately contract upon any ſudden Evacuation. And therefore when any great Artery is wounded, the Animal dies after a few Pulſations of the Heart, the great Artery being immediately emptied: But when a ſmall Artery at a great diſtance from the Heart continues bleeding ſlowly, all the Veſſels throughout the whole Body gradually contract, ſo that after many Pounds are evacuated, they may be as full as they were at firſt, and conquently the Animal not ſo much as faint, the Veſſels in the Brain being ſtill kept full, and the Spirits driven forwards in the Nerves; nor can the Animal die till ſuch time as the Veſſels contract no more. It is for this Reaſon that we have no Obſervations, which give account of ſuch large Effuſions of Blood at Wounds of the great Arteries, as we have from the ſmall Veſſels of the Noſe, and from the *Hæmorrhoides*; and therefore Dr *Moulin*'s Determination of the Quantity of the whole Maſs of Blood, which is calculated from the Quantity voided at the Carotide and Jugular Veſſels, is much leſs than what others from the Obſer-

vation of *Hæmorrhagies* of ſmall Veſſels have determined it to be.

The Reaſon of fainting upon any ſudden Evacuation.

This Contractive or Elaſtick Power of the Veſſels is not equal in all Bodies; for in ſome it is greatly diminiſh'd by the Viſcidity of the Blood, and the Obſtruction in the Fibres and Capillary Veſſels; and therefore ſome Men may die of a much leſs effuſion of Blood than others, who perhaps may have a leſs Quantity of Blood. It is for the ſame Reaſon that ſome Perſons faint upon opening a Vein of the Arm, whilſt others do not. If this Elaſtick Power of the Veſſels is ſtrong and great, then as the Blood is let out, the Arteries of the *Pia Mater* contract, and are kept full as well as the Coronary Veſſels of the Heart, and conſequently there is neither Blood nor Spirits wanting for performing the Motion of the Heart; but it happens juſt otherwiſe, where this Elaſtick Tone of the Veſſels is wanting, that is, to ſuch as have a ſoft and looſe Fleſh, a lax and cachectick habit of Body; and therefore when they require bleeding, it is convenient to ſtop the Blood at ſmall intervals, to give the Veſſels time to contract, before the full Quantity that is deſign'd be drawn off; and if they are ready to faint, the ſurprizing them, by throwing cold Water in the Face, to cauſe a ſudden Contraction, and the putting of them into an horizontal Poſture, that the Veſſels of the Brain may fill, and the Blood from all the depending Parts, have a more eaſy Reflux, does prevent it. It is the want of the ſame Energy of the Veſſels that cauſes ſome to faint upon any ſudden Evacuation by Urine, Stool, or any other ways.

That

A Proof of this Reason. That this is the true Reaſon of fainting upon any ſudden or violent Evacuation, and not the drawing off of the Spirits (as is generally ſaid) appears not only from this, that ſuch as faint upon bleeding at the Arm, do not faint upon Cupping, tho' the ſame, or a greater Quantity of Blood be drawn off this way, but likewiſe from the fainting of Perſons tapped for an *Aſcites*, if it happens, that too great a Quantity of the Waters is drawn off at once. None can ſuppoſe that the Spirits, which are in the extravaſated *Lympha*, have an immediate Influence upon the Nerves and Heart, that their Subſtraction ſhould preſently drain the Nerves of Spirits; nor can any think, that the Spirits are ſo quickly ſpent, as immediately to ſuffer upon the account of the want of a Supply from an extravaſated Fluid: but the Caſe is this; In an *Aſcites*, the deſcending Trunk of the *Aorta*, and all its Branches being conſiderably compreſſed, the Blood muſt neceſſarily dilate the aſcending Branches beyond their natural Bigneſs; but, when the Waters are let out to any conſiderable Quantity at a time, the Blood has a more free Paſſage into the deſcending Trunk, the Sum of the Cavities of both Arteries is augmented, and the Quantity of Blood thrown out, every *Syſtole* not being greater, the Arteries cannot be ſo much dilated, and conſequently the Pulſe becomes ſmall and weak, and the Spirits therefore are but ſlowly propelled thro' the Nerves, the Blood flows but in a ſmall Quantity into the Coronary Veſſels of the Heart, and conſequently a *Syncope* muſt enſue, till the Veſſels can recover their Tone, and the Blood in all the Arte-

ries comes to an *Equilibrium*, and therefore it is neceſſary to rarify the Blood, and rouſe the languid Motion of the Spirits by a Cordial; or to compreſs the deſcending Trunk of the great Artery by compreſſing the *Abdomen*, as has been ſucceſsfully tryed by the learned Dr *Mead*.

That the Compreſſion of the deſcending Artery muſt throw a greater Quantity into the aſcending Branches is demonſtration, and that this Quantity is conſiderable, and does affect the whole Machine, is evident from the Fluſhing and Head-ach which ſome feel after a plentiful Meal, when the Stomach and Guts being loaded, preſs upon the deſcending Trunk, and contract its Cavity, which are the Cauſes why a greater Quantity of Blood paſſes into the aſcending Trunks; on the contrary, if the Cavity of the deſcending Trunk ſhould be dilated, there will be a leſs Quantity of Blood thrown into the aſcending Trunks, and conſequently the Effects on the Animal Body muſt be at leaſt as ſenſible.

This contractive Power of the Veſſels ought to be duly conſider'd before the leaſt Quantity of Blood be drawn, in moſt acute, as well as chronick Diſeaſes; for I could eaſily ſhew how it may be loſt to a great Degree, in a few Hours. And in no Caſe whatſoever is the drawing off a large Quantity of Blood at a time juſtifiable, ſince it may be done more ſafely, and to as good Purpoſe at ſmall Intervals. It is evident from the following Theory of *Secretions*, that both the Quantity and the Quality of the *Secretions* may be alter'd by Bloodletting, and therefore when the Blood is upon a Ferment,

The great Riſque in Bleeding, and the uncertainty of its Conſequences.

and

and generates new Cohefions, of whofe Nature we are ignorant, it is a Rifque, which without evident and cogent Reafons ought not to be run. But to return,

A greater Quantity of Blood proved from the Obferva-tions of Phyficians.

If we give any Credit to the Obfervations of Phyficians, we muft believe the Quantity of Blood in the Human Body to be above 25 pound Weight. (*a*) *Rulandus* tells us, that he cured one of a bleeding at the Nofe, after he had bled in one Day about Ten pound Weight. (*b*) *Petrus Borellus* obferves, that a full bodied jovial Taylor loft Ten pounds of Blood by the *Hæmorrhoides*, and that he cured him with the Syrup of dried Rofes. (*c*) *Schenckius* quotes *Montanus* for one that voided two pounds and more of Blood, by the Piles, every Day for forty-five Days together, and was afterwards cured. (*d*) *Bartholin* fays, that he faw one vomit fixteen Pound of Blood without the leaft ill Confequence. And he takes Notice of one who bled forty-eight pound in three Days by the Nofe, from *And. Argolus.* (*e*) *Sckenckius* has feveral Obfervations of profufe *Hæmorrhagies* of the Nofe. He mentions a Nun of a thin Habit of Body, who, by bleeding at the Nofe, fpitting of Blood, and with Urine, voided eighteen pound of Blood; fhe was cured by one Drachm of *Philonium Perficum*. *Brafavolus* cured a Lady of a bleeding at the Nofe; the Blood which he weighed, befides what fell upon the Ground, Linnen, and Cloaths, was eighteen pound. *Marcellus*

(*a*) Rulandus, Curat. 57. Cent. x. (*b*) Cent. iv. Obf. lviii. (*c*) Lib. tert. Obf. clx. (*d*) Cap. de Corde. (*e*) Lib. de Capite Obf. cccxxxiii.

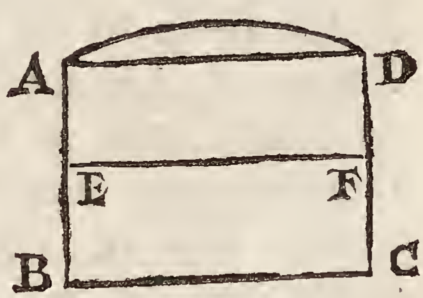
Donatus

Donatus recovered one of a bleeding at the Nofe, who in two Nights and one Day, bled above twenty pound Weight, as he found by weighing it. And at laft he tells us of one, who, in fix Days, bled forty pound at the Nofe. In the *Acta Eruditorum Lipfiæ*, for the Year 1688, we have an Account of a young Man about twenty-five Years of Age, of a thin Habit of Body, and a bilious Conftitution, who after various paffions of his Mind, bled at his Nofe, in ten Days time, feventy-five pound of Blood, and was afterwards reftored to a better health than he had before.

Now if the Quantity of Blood in the Human Body was not confiderably greater than its common Eftimate, thefe Perfons could never have furvived fuch profufe Effufions of their Blood. All of them bled more than Dr *Moulin* reckons to be in the Body, and many of them more, and almoft double of the largeft Quantity, which is allowed of by any: fo that either we muft deny thefe Matters of Fact, or we muft own, that our higheft Eftimates of the Blood fall much fhort of the true Quantity. Without doubt, Men differ in the Quantities of their Blood, as well as in the Weight of their Bodies: But none of thefe above-mentioned are noted to have been of a full Habit of Body, except *Borellus*'s Taylor; and it is particularly faid of the Nun in *Sckenckius*, that fhe was a fpare and thin Woman, and that her bleeding could not proceed from a *Plethora*.

That

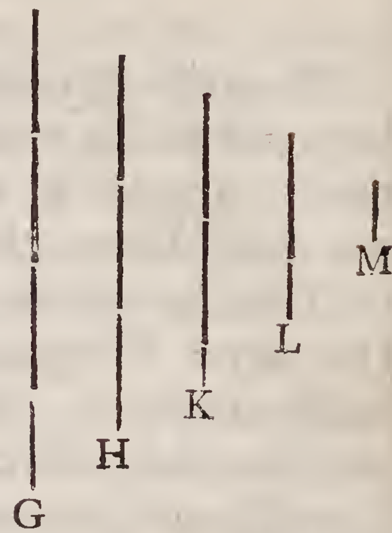
That the Quantity of Blood is confiderably larger than the common Computation, will, I think, appear if we confider the Quantity of our daily Evacuations, which in a fettled State of Health, when the Body is every Day of the fame Weight, is the fame in Quantity with our Food. Let us therefore fuppofe that we eat and drink four pounds every Day to fupply our daily wafting, that the Body may continue of the fame Weight. This Aliment equally mixing with the Blood, and being affimilated to it, will with it be fecerned in the Glands, fo that both old and new will go off together; I fhall at firft fuppofe in proportion to their Quantities. Now in this Cafe, I would know how much of the old Blood remains in the Body after any certain fpace of time. This Queftion is the fame as if you would fuppofe a Veffel of Wine holding 200 quarts, and that out of it were drawn four quarts every Day, and conftantly filled up again with Water. *Quæritur*, How much Wine will remain in the Veffel at the end of any number of Days?



Let ABCD reprefent the Veffel at firft full of Wine, and then let the Quantity AEFD be drawn out, then the firft Quantity of Wine will be to the Wine that remains, as the Veffel AC is to EC, that is as DC to FC; fo that if the Line G reprefent the firft Quantity of Wine, and if

G;

G : H : : CD : CF, H will repreſent the remaining Wine after the firſt drawing. And ſeeing the Veſſel is ſuppoſed to be filled up again with Water, and both Wine and Water equally mixed together; the Quantity of Wine that is drawn off the ſecond



Time, will be as the Quantity of Liquor that is drawn off; and the Quantity of Wine that remains, will be as the Quantity of the remaining Liquor, that is as CF; or the Wine that remains after the firſt drawing will be to the Wine that remains after the ſecond drawing, as DC to CF. And if H : K : : CD : CF, then K will repreſent the Wine remaining after the ſecond drawing, and G, H, K, will be continual proportionals. After the ſame manner if K : L : : CD : CF, L will repreſent the Wine remaining after the third drawing, and the Quantities which ſhew what remains after each drawing, are the terms of a ſeries of Geometrical Proportionals.

Now let us ſuppoſe the Quantity of Blood in the Body to be only 20 ℔ then we have a ſeries of Geometrical Proportionals, whoſe common *ratio* is 20 to 16, or 10 to 8. If therefore we take the firſt term to be 1, the ſecond will be 1,25. whoſe Log. 0.0969100 multiplied by 30 (the number of Days in a Month) is 2.9073000, which ſubſtracted from the Log. of 20 (the number of pounds of the Blood) *viz.* 1.3010300, gives the Log. of the thirtieth term 8.3937300, to which the number

ber anſwering in the Tables is 0.024758; and therefore after thirty Days the Quantity of old Blood remaining in the Body will be the 0.024758 part of a Pound, which is a little more than three Drachms. This is a quicker change of Blood than I believe ever entred into the imagination of any Man; and I am apt to think that every one who reads it, will readily ſave me the trouble of diſproving what at firſt ſight is altogether incredible. If therefore our Evacuations are only from the Blood, the Quantity of the Blood muſt be much more than 20 ℔ But thoſe who aſſert that the Blood is 20 ℔ only, will, I ſuppoſe, ſay that the great Quantity of our Evacuations comes from the decaying and waſting of the ſolid Parts. Let us therefore ſuppoſe that a Body which contains 20 ℔ of Blood weighs 160 ℔ we will examine how much of the old Body muſt remain at the Year's end. If we waſte every Day four Pounds, the *ratio* of the terms will be 160 to 156, or 80 to 78. If therefore the difference of their Log. be taken and multiplied by 365, the Days of a Year, and the Product ſubſtracted from the Log. of 160, there will remain the Log. of the 365th term of the ſeries, which ſhews the Quantity of the old Body remaining, and it amounts to three Drachms. Now can any one believe that our Fleſh and ſolid Parts change almoſt all every Year? And yet even in this Caſe there will not remain at the Year's end twenty Grains of the old Stock of Blood.

There is one thing farther to be conſidered before this Argument can be ſaid perfectly to conclude, and that is, whether or no this great Evacuation

Evacuation may not proceed from our Aliment it ſelf. I own I do think that it does in a great meaſure, and I am willing to make any reaſonable allowances for it, and then let us ſee what the Conſequences will be. I ſhall therefore ſuppoſe that of the 4 ℔ which we eat and drink, 3 ℔ goes off immediately, that is, the ſame Day; and then the Caſe is the ſame as if our ſuſtenance weighed only one Pound, and our Evacuations were of the ſame Weight. Now if upon this ſuppoſition we enquire how much of the old Stock of Fleſh and Blood remains at the Year's end? The Anſwer will be little above 16 ℔ of which two Pound is Blood, if that was at firſt only 20 ℔ and 126 ℔ of ſolid Fleſh muſt have waſted in twelve Months time, which it is hard for common Senſe to believe.

But if we puſh this Conſideration of the greateſt Part of our Aliment being excrementitious a little farther, we ſhall find our Argument ſtill ſtronger. For let us ſuppoſe that $\frac{1}{8}$ Part of it only is fit to be aſſimilated into Fleſh and Blood, and undoubtedly conſidering our Food is partly made up of the Parts of Animal Bodies, and partly of Vegetables, which are compoſed of Tubes analogous to thoſe of the Animal Body, it muſt be granted to be a very fair allowance. And indeed it can hardly be imagined that Nature, in providing us with a proper Aliment, ſhould burthen our Stomach, Digeſtion, and Blood, with 7 Parts in 8, of what was only fit for Excrement. However, I ſhall ſuppoſe that only $\frac{1}{2}$ ℔ of what we eat and drink in a Day is fit to be converted into good Blood. This half Pound

pound of fresh and good Blood thus purified from all excrementitious Particles, must necessarily be fit for all the uses of the animal Body, and when converted into Flesh, must remain good and sound, without decaying, as long as any Parts can do. Thus those Parts which have been longest in the Body will decay and waste first, and those which were last added will remain the longest. If therefore the Body continues of the same Weight, there must go off half a Pound of the old Body to make way for the half pound of good nutritious Blood added every day, and so in less than a year the whole Body must be changed. Thus I have considered the several sources which can be supposed to supply our daily Evacuations, and do find that upon supposition that the Quantity of Blood in the Body is no more than 20 ℔. that the Consequences are such as are beyond all Credit; for can any man believe that either almost all the Blood changes every month, or all the solid Parts of the Body every year? and yet these are the Censequences of supposing the Quantity of Blood to be but 20 ℔ Weight. It does indeed necessarily follow from the foregoing reasonings that the Body changes much oftner than was commonly thought. The vulgar Opinion gave 7 years to complete a thorough Change of the Body; but for any reason alledg'd it might as well have requir'd 70. Now it appears that the Change is almost yearly, nor is there any thing incredible in this, if we suppose that the Bulk of the Body is Blood, and that the solid Parts, make up but a very small Part of it; and that these solid Parts, how great or little soever they are, seldom

ſeldom if ever change, ſome Reaſons incline me to believe.

For firſt, the Scars of the Cuts which Children receive in their Fingers and Faces never wear out when then they are old. The Marks of the Lance in bleeding always remain in the Arm, as do likewiſe the Inciſions made by cupping. The Pits and Seams of the Small Pox in a Child of a year old, ſpoil the Beauty of the Face at fifteen, and add to the Wrinkles of old Age. Nay all theſe Marks and Scars, inſtead of wearing out, as the Skin extends, are every way extended with it; and a Scar which in a Child was not half an inch long, comes to be above an inch when the Perſon is at full growth; and as it ſtretches in length ſo it does in width proportionably. Now if the ſolid parts of the Body were continually waſting and changing, theſe Cicatrices would daily grow leſs and leſs, and at laſt totally diſappear; new Particles filling up the place of the wounded ones as they decayed; but we find it quite otherwiſe, and therefore the Parts in which theſe Wounds were made always remain the ſame.

Another Argument to prove that the ſolid Parts of the Body are always the ſame, may be drawn from the Spots and Stains which are made in the Skin by Gun-powder, and other Mixtures, ſuch as are uſed in ſtamping the Skin at *Jeruſalem*, or as ſome *Indians* uſe in painting of their Bodies, and ſome amongſt our ſelves to make Spots in their Hands. For if the ſolid Parts which are tinged with theſe Mixtures waſted and decayed, the colouring would with them likewiſe decay. The new

Particles

Particles which are ſuppoſed to come in the room of the old decaying ones, tho' they may have the ſame Figure and Dimenſions with thoſe whoſe places they fill up, yet they cannot be ſuppoſed to have the ſame artificial Tincture: But theſe Stains generally remain for ever; and therefore the Parts ſo ſtained, are always the ſame without changing. From all which it follows, that our Bodies change much oftner than was ever imagined; that this Change is not of the ſolid Parts of the Body, but of the Blood; and that the Quantity of Blood muſt be vaſtly greater than the common Computation makes it to be. If it ſhould be objected to this quick Change, that we ſometimes find it very hard, after many years Application to correct and amend a vicious *Craſis* of the Blood; the Anſwer is eaſy, that as the new Juices mix with the old, they are aſſimilated into the ſame nature with the old, and are tainted with its Qualities. A little Ferment will affect a great Maſs of Fluids; and from thence it comes, that in ſome chronic Diſtempers, in which the Blood is apt to breed the ſame vicious ſort of Humour, after a long and judicious *Regimen* carefully obſerved, when the Blood is purified, and the Body reduced to a good State of Health; yet if the Quantity of a Grain remain of the noxious Humour, that ſmall Quantity will in proceſs of time taint the whole Humours in the Body, and the Diſtemper return as bad as before. Now tho' the old Stock of Blood (as has been ſhewn) daily leſſens, yet it never can be totally purged out of the Body; for being equally mixed and diluted with the new Blood, ſome of it muſt

always remain, whilſt there is any of the other. And from thence proceeds the Difficulty of rectifying ſome bad Conſtitutions, the ſame humour will ſtill be growing upon you, reduce it never ſo low, unleſs it is totally eradicated; and that it never can be totally eradicated by all or any one ſort of Evacuation, is likewiſe evident from what has been ſaid. Indeed Salivating, or proper Purges adapted to the nature of the Humour, when the Blood overflows with it, may at firſt be abſolutely neceſſary, and cut off a great deal of labour; but then as the Humour grows leſs, every Day's Evacuation carries off leſs and leſs, and can never poſſibly draw all off. If therefore, we would complete the Cure, the Patient muſt continue a long time in the uſe of alterative Medicines, that the Nature of that Humour may be changed which could not be carried off.

Having therefore ſufficiently proved that the Quantity of Blood in the Human Body, muſt be much greater than the common Eſtimation: I ſhall in the next place endeavour to ſhew how much at leaſt it is.

What is here meant by Blood.

By Blood I underſtand not only the Fluid in the Veins and Arteries, but likewiſe that in the Lympheducts, Nerves, or any other Veſſel of the Body, becauſe they are all Parts of the Blood, ſeparated from it by the force of the Heart, and many of them by the ſame force return to it again; and therefore, when I ſpeak of the Quantity of Blood in the Body, I would be underſtood to mean the Quantity of circulating Fluids, of what kind ſoever they be: At other times I ſhall uſe the Word in its common Signification.

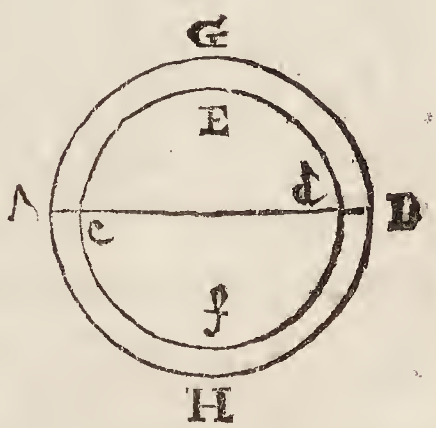
I ſuppoſe

The whole Body made of Veſſels and Fluids.

I ſuppoſe the whole Body is nothing but Tubes or Veſſels full of Blood or Liquors ſeparated from it. This is now agreed on by all who underſtand the Fabric of the Body, and is evident from nice Mercurial Injections of the Veſſels, and may be plainly ſeen by Microſcopes. *Leeuwenhoeck* ſays, that there ſeemed to be above 10000 Blood-veſſels in the ſpace of $\frac{1}{4}$ of an Inch ſquare. You cannot prick your Finger with the fineſt Needle, but it wounds a Blood-veſſel. The Fibres of the Muſcles (which make by far the greateſt part of the Body) are full of Blood, and the Fibres of the Bones, are not without their Fluid, as I ſhall ſhew afterwards.

The Proportion of the Fluids to the Veſſels.

I therefore conſider the Veſſels full of Fluids, as ſo many ſolid Cylinders, and the Coats of the Veſſels, as ſo many concave Cylinders of the ſame height, whoſe proportion to one another may be thus determined. Let A B G H repreſent the circular Section of a Veſſel, of which call the Diameter A B, a, the Diameter $c\,d$ of the Cavity, $a - b$. Circles being to one another as the Squares of their Diameters, the Square of the whole Section is a^2, the Square of the Cavity is $a^2 - 2\,a\,b + b^2$, which being ſubſtracted from the Square of the whole, there remains $2\,a\,b - b^2$ proportional to the annular Space ABGH $c\,d\,f$ E, and conſequently in a Body compoſed of ſuch Veſſels, filled with Fluids, the Fluids will be to the



 Solids,

Solids, or Coats of the Veſſels as $a^2 - 2\ ab + b^2$ is to $2\ ab - b^2$.

Several ſorts of Veſſels.

Now if the whole Body was compoſed of Veins or Arteries, it were eaſy to determine the Quantity of Blood in the Animal Body. But we find, that the Coats of the Arteries have a greater Proportion to their Cavities, than the Veins have to theirs; and theſe again have a greater Proportion to their Cavities, than the Lymphatic Veſſels have to theirs; and there may be one Proportion of the Nerves, another of the Fibres of the Muſcles, and another of the Fibres of the Bones; all which ought to be known before the Quantity of Blood in the animal Body, can be exactly determined.

The thickneſs of the Coats of the Blood-veſſels may be thus exactly found, Slit a piece of a Blood-veſſel, and reduce it to the Form of a *Parallellogram*, then weigh it in Water, and by that means find the Weight of Water equal to it in bulk. This Weight reduced to decimal Parts of an Inch call, d, and ſuppoſe the length of the *Parallellogram* equal to e, and its breadth $= c$, its thickneſs f. Then $d = e\,c\,f$ and conſequently $\frac{d}{e\,c} = f$ the thickneſs of the Coat of the *Veſſel*.

The Proportion of the Blood in the Arteries to the Coats of the Arteries.

Thus a piece of the *Aorta* of a Calf I found to be equal to 0.071897 parts of an Inch of Water, its length was 1. 1, its breadth 1.28, and therefore its thickneſs was 0.051. The Diameter of the Cavity of this Artery was 0.407, and conſequently $a^2 - 2\,ab + b^2$ equal to 0.165649, and $2\,ab - b^2$ equal to 0.093432, and therefore if the whole Body was

was composed of Arteries or Vessels which had the same Proportion to their Cavities, as the Arteries have to theirs, the Blood would be to the solid Part of the Body, as 1.7 to 1, and a Body weighing 160 Pound, would have 100 Pound of Blood.

The Proportion of the Blood in the Veins to the Coat of the Veins.

After the same manner I found that the thickness of the Coats of the *Vena Cava* of the same Calf was 0.0097. The Diameter of this Vein was 0.617, its Square is 0.380689, and $2\,a\,b - b^2 = 0.02431596$. If therefore the Body was composed of Vessels, whose Coats had all the same Proportion to their Cavities, that the Coats of the Veins have to theirs, the Blood would be to the solid Part of the Body, as 15.6 to 1, and in a Body weighing one hundred and sixty Pound, there would be above one hundred and fifty Pound of Blood.

How the Bulk of the Blood increases upon a small increase of the Diameter of the Blood-Vessel.

It is to be observed, that these Proportions of the thickness of the Coats of the Vessels to their Cavities were taken when the Vessels were empty, and consequently when the Coats were thickest, and the Diameter least, for all the Vessels, especially the Arteries, shrink and contract when they are empty. Let us suppose the Diameter of the Cavity of the Artery which was 0.407, to be increased 0.1, the Square of this Cavity would be 0.257049, and consequently the Blood would be to the solid Part of the Body, as 2.7 to 1. If the Diameter were increased 0.2, the Blood would be to the Vessels, as 3.9 to 1. If 0.3, it would be as 5.3 to 1. From these Proportions one may judge more exactly to what Degree the Blood is heated or rarified in inflammatory Fevers, by the largeness of the Pulse: As also

how ſmall a Quantity of Blood muſt be thrown out at the Heart every Syſtole in languid Fevers, when the Pulſe is ſmall.

How the Arteries may be dilated in Aneuriſms. It is ſurpriſing to ſee how little the increaſe of the Diameter of the Cavity of the Artery diminiſhes the thickneſs of its Coats; for if we add to the Square 0.257049, the annular Space, which we found to be 0.093432, then 0.350481 is the Square of the Diameter of the whole Artery, that is both of its Coats and Cavity. The Square Root of this Number is 0.592, from which if we ſubſtract the Diameter of the Cavity, there remains 0.085, the half of which 0.0425 is the thickneſs of the Coat of the Artery. Thus I find that the Diameter of the *Aorta* may be increaſed eight times its firſt bigneſs before its Coats become ſo thin as the Coats of the *Cava*. This ſhews how prodigiouſly Aneuriſms may dilate the Arteries; and how when a large Trunk of an Artery in the Arm, Leg, or Thigh, is tied, the ſmall Arteries (which all communicate with one another) may dilate to carry on the Circulation of the Blood.

Of the Quantity of the Blood in the Fibres of the Muſcles. The next ſort of Veſſels I come to conſider is the Fibres of the Muſcles, which, though they may be more bulky, yet they cannot be more numerous than the Arteries; for every Fibre muſt have at leaſt one Artery, and it is probable it has ſeveral. They, without doubt, have conſiderable Cavities, ſeeing they ſwell, are blown up, and thereby conſiderably ſhortned when the Muſcles act. And their ſides can be but thin, or elſe they could not be diſtended by ſo ſmall a Force. Beſides, the Blood appears as plainly through them, as it

does through an Artery of an equal bignefs, and therefore we cannot judge their fides to be thicker than the Coat of an Artery of an equal bignefs. The Proportion of the thicknefs of their fides to their Cavities is not to be taken after the manner we have done thofe of the Veins and Arteries; but that we might make fome Eftimate of it, I made the following Experiment.

I took a piece of the Inteftine of a Dog, with part of the Mefentery and *Pancreas Afelli*, and having carefully emptied it of all its Contents, I weighed it exactly with all the Blood in the Veffels, its Weight was one Ounce and a half, one Drachm and eighteen Grains; then I injected warm Water into the Artery, and having fufficiently wafhed out all the Blood, I blew it up, and hung it up to dry in the Shade; after it had dried about a Week, I weighed it again, and its Weight was two Drachms, two Scruples, and eleven Grains: by which it appears, that it had loft 627 Grains, and that there remained only 171 Grains. Now this lofs could be only of the Fluids, which being diluted with the warm Water, were the more eafily evaporated, and therefore if the Blood in every part of the Body bore the fame Proportion to the folid Part, that it does to the folid Part of the Inteftines, their Proportions would be 3.6 to 1, and a Body weighing one hundred and fixty Pound would contain one hundred and twenty-five Pound of Blood, fo that even the Fibres of the Mufcles are lefs folid than the Arteries. But the Fibres which perform the Periftaltic Motion of the Inteftines, are not fo fpongy as

the Fibres of the Mufcles, for we find them firmer and harder; befides, if we confider that the Periftaltic Motion is performed by a very fmall contraction of the Fibres, for which a very fmall Inflation will fuffice; but the Contraction of the Fibres of the Mufcles being great, they muft be confiderably inflated, and confequently more fpongy, and capable of receiving a larger Quantity of Blood, than the Fibres of the Inteftines; and therefore it is evident, that in the Mufcles which make up far the greateft part of the Body, the Proportion of the Blood to the folid Fibres muft be above 3.6 to 1, or almoft as 4 to 1.

Of the Quantity of Fluids in the Nerves.

To know what Proportion the Fluids of the Nerves bear to the folid Part of the Nerves. I dried a piece of the *Medulla Spinalis* without any Art or Preparation, excepting the flitting of it; and I found that it loft near $\frac{3}{4}$ths of its Weight, fo that it appears, that even the Nerves are not more folid than the other Parts. And as to the Lymphatic Veffels, I believe every one will eafily agree, that the Fluids in them bear a much greater Proportion to their Coats, than what has yet been found.

Of the Quantity of Fluids in the Bones.

The Bones of all the Parts in the Body feem to bid the faireft for Solidity, and yet even their Fibres are not without their circulating Juices; what elfe is the *Callus* which unites and cements the Extremities of broken Bones? In it there are no Fibres, nor parts to be diftinguifhed, but it appears like an uniform infpiffated Juice. At whatever Time or Age the Misfortune of a broken Bone happens, this Juice

Juice is always at hand, which ſhews, that it is always circulating, though ſlowly: If it ſtagnated, it would harden, as it does when it is extravaſated, and forms a *Callus*; and conſequently all the Paſſages being obſtructed, no broken Bone could unite. This Juice is like to the viſcous Sap of Trees; for without doubt a Fluid may move as eaſily through the Fibres of the Bones, as through the Fibres of an Oak. The Excreſcencies of the very Subſtance of the Bones, their Nodes, Swellings, and ſoftning like Wax, of which there are ſeveral inſtances to be found in Authors, even of Perſons grown in Years, do ſufficiently evince a fluid circulating thro' their Fibres. No doubt but that the older we grow, the narrower are the Channels of the Fibres, the viſcid Fluid hardening towards their Sides, and after Death entirely obſtructing them, ſo that the whole Fibre appears ſolid; but ſtill it is really no part of the Fibre, no more than the Cruſt with which ſome Waters line the Pipes through which they run, is part of the wooden or leaden Pipe, or the Glew in which a Sponge has been ſoaked, can be ſaid to be part of the Sponge: And as theſe may be taken out, without taking away any of the Subſtance in which they are contained, ſo likewiſe may this Fluid in the Bones. What elſe is the Jelly made of Harts-horn, but a Fluid extracted by boiling Water, the Fibres and Subſtance of the Horn ſtill remaining undiſſolved? Is not the Jelly extorted by *Papin*'s Digeſter, out of dry and ſolid Bones, the ſame Fluid? That I might know what Proportion it bears to the Fibres of the Bones, I cauſed the

the Bone in the Knuckle of Beef, being firſt boiled and the Marrow taken out to be put in the Digeſter. Before it was put in, it weighed 22 Ounces 6 ½ Drachms, when it was taken out and dried, it weighed eleven Ounces 1 ½ Drachm, ſo that it loſt above half its Weight; and yet the Texture of the ſmalleſt Fibre in the moſt ſpongy part of the Bone was not broken, and the middle or more ſolid Part appeared to be made of parallel *Laminæ*, of which four or five would hardly exceed the thickneſs of a Sheet of Paper. And I doubt not but that if the Experiment had been made upon younger Bones, the Proportion of the Fluids to the ſolid Part would have been found to be much greater. Now if the Bones contain ſuch a Quantity of Fluid, what do the *Tendons*, *Membranes*, *Ligaments*, and *Cartilages*, which are much ſofter Subſtances, and which, upon boiling, likewiſe yield a Jelly? And is not Glue, which is extracted out of the Skins of Animals, ſuch a ſort of Fluid? So that it is highly probable, that there is not a Fibre in the whole Body, in which ſome Fluid or other does not circulate, but which hardening after Death, and perhaps, ſome part of it before, no Elixation whatſoever can extract.

The Coats of the Veſſels compoſed of other Veſſels.

Thus have I conſidered the ſeveral ſorts of Subſtances in the Body, and ſhewn what Proportion the Fluids in each of them bear at leaſt to their ſolid Parts; I ſay at leaſt, for no Preparation nor Art can extract a Fluid ſo viſcid, and ſo apt to harden, as the Blood is, out of the innumerable Meanders of ſuch infi-

nitely

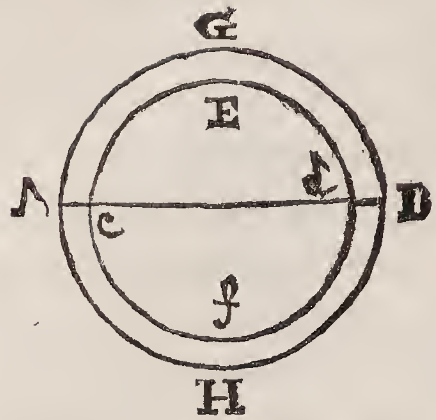
nitely ſmall Veſſels. I have alſo ſuppoſed the Coats of the Veins and Arteries to be perfectly ſolid, that is, without Fluids, whereas it is evident to the naked Eye, and agreed on by all Anatomiſts, that they are compoſed of Myriads of Veins and Arteries. What an innumerable Company does an inflammation of the Eye ſhew upon the *Tunica Conjunctiva?* And are there not many more to be diſcovered by Microſcopes, and the finer the Glaſſes are which we uſe, ſtill the more Veſſels we diſcover; ſo that if we can ſee no more, it is only becauſe our Glaſſes are not better. Whoſoever is acquainted with the Preparations of the curious Dr *Ruyſch* would be apt to believe, that the whole Body, and all its Fibres were nothing but Blood-Veſſels.

The Quantity of Fluids in the Coats of the Arteries determined by an Experiment.

A piece of the *Aorta* of a Calf weighed two hundred and forty Grains, when dried it weighed eighty Grains; ſo that from this Experiment it appears, that the Blood in the Coats of the Arteries is to the Coats as 2 to 1, which is a greater Proportion than the Blood in the great Arteries bears to their Coats, and yet we cannot ſuppoſe that any more than the thin part of the Blood was exhaled.

A general Method to determine the Quantity of Fluids in the Coats of the Veſſels.

Now therefore ſuppoſing that the Veſſels are made up of others, full of Fluids, and that there is the ſame Proportion of the Fluids to the ſolid Parts in each of them; the Quantity of Blood in the Body may be thus determined. Let the Annular Space



Space GABH, Ecfd, be to the whole Circle AGBH, as 1 to a, then in a Body compoſed of ſuch Veſſels filled with Fluids, the Fluids will be to the Solids, (if the Annular Space is ſolid) as $a - 1$ to 1. But if this Annular Space is likewiſe compoſed of the ſame ſort of Veſſels, then in the whole Body the Fluids will be to the Solids, as $a^2 - 1$ to 1: And again, If theſe leſſer Veſſels are compoſed of others ſtill leſs than themſelves, then the Fluids will be to the Solids as $a^3 - 1$ to 1: and if there ſhould be four ſuch orders of Veſſels, the Fluids will be to the Solids, as $a^4 - 1$ to 1, if five, as $a^5 - 1$ to 1: if ſix, as $a^6 - 1$ to 1: ſo that the Proportion of the Fluids to the Solids may be increaſed *in infinitum.* In the Arteries a is equal to 2.7, in the Veins it is equal to 16.6, and according to the ſeveral Series of Veſſels, the Blood will be to the ſolid Part of the Body in theſe Proportions.

1.7	to 1	15.6	to 1
6.2	to 1	274.5	to 1
18.6	to 1	4573	to 1
52.1	to 1	75932	to 1
142.4	to 1	1250492	to 1
286.4	to 1	20758082	to 1

If

If the Body is compofed of Veffels, whofe Coats are made of other Veffels, and thefe again of others, as has been faid; then the Bodies of the *Animacula in femine*, or the *Prima Stamina Vitæ* may be increafed to any bulk, and the Coats of the Veffels fo far as we can difcern grow thicker and thicker, without the Addition of any Subftance to the Veffels, only by increafing the Quantity of Fluid, with which they are filled. For as the large Veffels fwell, fo likewife muft the fmall ones, of which their Coats are compofed, down to the very laft; and the fwelling of the feveral Orders of Veffels muft neceffarily increafe the Thicknefs of the Coat of that Veffel which they compofe: So that by increafing the Number of the Orders of the Veffels, the Coats of the firft Order of Veffels may be increafed to any Degree, and yet the Diameter of the Veffels which compofe thefe Coats not greater than a given Line.

That all the Solids in an Animal Body at full growth, may be no more than what was in the Animalcula in femine.

That the coats of the great Veffels are compofed of fmaller Veffels, is Matter of Fact; and we know nothing to the contrary, but that thefe fmall Veffels may be compofed of others ftill fmaller than themfelves. We know not how many *Laminæ* or *Folds* there are in any Membrane of the Body. That excellent Anatomift Mr *Cowper* informs us, that every Membrane is Veficular, and may be blown into innumerable Cells. That tranfparent Membrane the *Cornea* of the Eye confifts of as many parallel *Laminæ*, as the niceft Hand of the moft expert Anatomift can raife. That delicate thin Membrane which involves the Brain, divides it felf into two *Laminæ*. And

it is very probable, that the *Hydatides*, of which ſeveral are found within one another, are nothing but the Coats of the Lymphatic Veſſels, diſtended and ſeparated by the *Lympha*, and yet it is hard to conceive any thing thinner than the Coat of a Lympheduct, which is not viſible but when it is diſtended with *Lympha*. If we know not the Number of *Laminæ* which compoſe the Membranes, how can we reckon the Number of Fibres, of which the *Laminæ* conſiſt? Or how ſhould we diſcover the Number of Fibres, of which each Fibre is made up? *Leeuwenhoeck* tells us, that the Fibre of a Muſcle which was nine times ſmaller than a hair of his Beard was made up of a hundred ſmaller Fibres, and yet each of theſe muſt have had Nerves, Veins, and Arteries, and perhaps each of them made up of a hundred more: For how many Series of Veſſels any one Veſſel is made up of, is what no Microſcope can diſcover; becauſe only one Order can lie at a time in the *Focus* of the Glaſs, and if more could, their ſeveral Refractions would confound the Sight.

As it is certain that all the larger Veſſels are compoſed of leſſer ones, and highly probable that theſe leſſer are made up of ſuch as are ſtill leſs, and that there may be ſeveral gradations of Veſſels leſs than one another in the Fabric of every larger Veſſel; ſo there are ſome inſtances which ſeem to prove that the parts of the Body may be increaſed almoſt to any Bigneſs without the addition of any ſolid Subſtance, only by the ſwelling of the ſeveral orders of Veſſels, I ſhall give one very remarkable and evident inſtance of this kind,

and

and that is the *Uterus*, which in Geſtation is diſtended to a very great degree; and as it increaſes in bulk, ſo its Coats grow thicker and thicker; and yet all this is without any addition of Subſtance to that of the Womb, its Veſſels being only ſwelled by the Affluence of Blood; for after Delivery theſe Veſſels ſubſide again, and the Womb becomes leſs again; tho' not ſo little as it was at firſt, becauſe the Veſſels of which it is compoſed are more dilated, and the Blood ſtill maintains a freer circulation than at firſt. Another inſtance of this kind is the Breaſts, which are increaſed conſiderably by the Flux of Milk, and which ſink again as the Milk goes away. We might likewiſe obſerve that in an *Aſcites* as the *Peritoneum* is diſtended, ſo it increaſeth in thickneſs; and thoſe who are converſant in Diſſections, know that all Membranes which are preternaturally diſtended, become always proportionably thicker.

Nutrition nothing but Diſtention.

If all the ſolid part of the Body was contained in the *Animalcule*, then *Accretion* and *Nutrition* are nothing but the Repletion and Diſtention of the Veſſels, and it is eaſy to conceive how *Helmont*'s Tree grew from five Pound Weight in five Years time, to one hundred and ſixty nine Pound, only by the addition of Water. Nor does this at all contradict the Ingenious Dr *Woodward*'s Experiments concerning Vegetation, but his Experiments are rather a Confirmation of this Doctrine. For the fewer terreſtrial Particles are contained in the Water by which any Plant is nouriſhed, the quicker the Water paſſes off thro' the Pores or Excretory Ducts of the Plant,

Plant, and confequently the lefs the Veffels are diftended; but if the Water is impregnated with a large Quantity of Terreftrial Matter, it cannot pafs off quickly, but being retained in the Plant, the Veffels muft be diftended, and confequently the bulk of the Plant increaf-ed. That the fewer terreftrial Particles the Water contains, the quicker it paffes off, is evident from Experiments: For two Plants of Mint near of the fame Weight, fet at the fame time, the one in Rain-water and the other in *Thames*-Water (which is more copioufly ftored with terreftrial Matter) this did thrive to al-moft double the bulk of that, and with a lefs Expence of Water; yet the Experiments do fufficiently evince, that Plants require a pro-per Nourifhment, as well as Animals, without which they can never kindly thrive. For Life is continued, and all its Functions performed, by the ftraining off of feveral forts of Juices from the common Fluid, which in Animals is called Blood: But if this common Fluid can-not afford thefe Juices, or is not fit to be turn-ed into them, then that Body whether vegeta-ble or animal, muft turn fickly, and at laft die. Some forts of Water are more eafily tranfmuted into the Juices of fome Plants than others, for we fee fome love a very dry and fome a very wet Soil, and fome will grow in Water alone, and therefore it was that *Hel-mont*'s Willow Tree grew to fuch a bulk.

No equi-vocal Ge-neration.

If the moft proper Food can only diftend but not increafe or add to the Subftance of the folid part of the Body, how much more rea-fonable is it to fuppofe that no matter, howfo-ever difpofed, can at firft frame thefe folid parts,

parts, without an Omnipotent Power immediately actuating it.

And does not all that has been ſaid demonſtrate not only the Poſſibility, but likewiſe the great Probability of that Suppoſition, which the Reverend and Learned Mr *Clark* uſes to ſhew the Poſſibility of the Reſurrection of the ſame Body; for if all the ſolid parts are no more than the Original *Stamina*, and all Nouriſhment only a Fluid in a perpetual Flux, then no part of an animal Body can become part of another animal Body; but the Body is always the ſame, from the firſt Moment of Life to the laſt.

The Poſſibility of the Reſurrection of the ſame Body.

But whether the Coats of the Veſſels are compoſed of others, or not, the Experiments I have brought do clearly demonſtrate, that the Fluids in the Body are to the Solids at leaſt as 3.9 to 1, and therefore in a Body weighing one hundred ſixty Pound, there muſt needs be one hundred twenty ſeven Pound of Blood. From which Quantity, that I may put the matter out of all manner of Diſpute, I ſhall deduct the Weight both of the Fat and Bones, tho' I think that ſome Arguments might be alledged to prove that even the Fat circulates, and I have already ſhewn that there is a Fluid in the Bones.

The Weight of the Fat and Bones deducted from the Quantity of Blood.

In a Body weighing one hundred ſixty Pound, I ſhall ſuppoſe that the Fat is an Inch deep all round the Body, and in ſuch a mean Weight, I believe this will be ſufficient to anſwer for all the Fat every where elſe. Dr *Wainewright* reckons the Surface of the Body meaſures fifteen ſquare

Feet, and therefore the Fat muft be one hundred eighty cubic Inches. Now a cubic Inch of Fat weighs about half an Ounce, or fomething more, and therefore the whole Fat of the Body of a Man weighing one hundred fixty Pound is ninety Ounces, or five Pound ten Ounces; but I fhall fuppofe it to be feven, and that the Bones weigh twenty Pound, and there remains one hundred Pound for the Quantity of Blood in a Man weighing one hundred fixty Pound.

ESSAYS
ON
SEVERAL PARTS
OF THE
Animal Oeconomy.

ESSAY II.

Of the Velocity of the Blood.

ALL who have wrote of the Velocity of the Blood, ſince the Diſcovery of its Circulation by the immortal Dr *Harvey*, have contented themſelves only to calculate the Quantity, which paſſes through the Heart in ſome determined time: But none has as yet given us the abſolute Velocity with which it is thrown out of the Heart, runs through the *Aorta*, or any of its Branches. Many have indeed ſpoke of the rapid Motion of the Blood, and that it muſt be much greater near the Heart, than in the Extremities; but how

much greater it is in that than in theſe, or whether it moves through the *Aorta*, at the rate of 5, 10, 100, or 1000 Feet in a Minute, is what has never as yet been determined; tho' next to the Circulation of the Blood it ſelf, it ſeems to be a thing of the greateſt Moment for explaining of the animal Oeconomy. After the Motion of the Blood was once determined, methinks it was but natural to have enquired in the next place with what Degree of Velocity it moved.

The Velocity of the Blood in the *Aorta* may be thus determined.

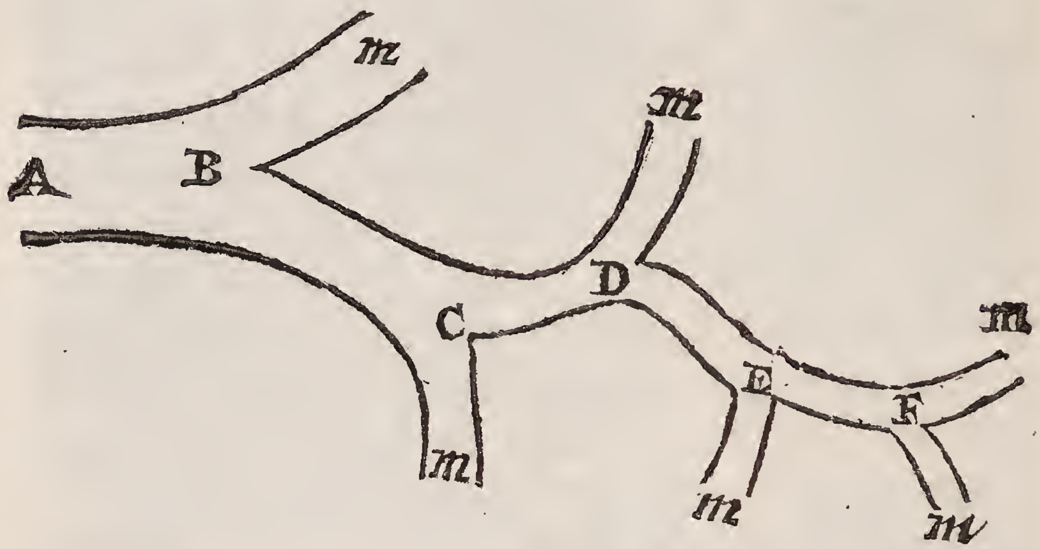
The Velocity with which a Fluid flows out of any Orifice uniformly and always running in the ſame Quantity, is equal to the Velocity of a Body which deſcribes a Space of the ſame length with that of a Cylinder, whoſe Baſe is equal to the Orifice, and whoſe Magnitude is equal to the Quantity of the Fluid that runs out in the ſame time, as 'tis evidently ſhewn in the *Lectiones Phyſicæ Jo. Keil*, *pag.* 114. Now ſuppoſe the Heart contracts eighty times in a Minute, and that each Contraction throws into the *Aorta* one Ounce of Blood. An Ounce of Blood is equal in bulk to 1.659 inch, and conſequently 80 Ounces are 132.72 inches. The Diameter of the *Aorta* in a middle ſized Man, I have found to be 0.73 parts of an inch, and therefore its Orifice is 0.4187, by which divide 132.72, the Quotient 316 inches or 26 feet gives the length of the Cylinder, or the Space through which the Blood will go in a Minute, ſuppoſing it were conſtantly going out of the Heart with the ſame Velocity: But becauſe of the

Diaſtole

Diaſtole of the Heart, which is at leaſt two thirds of the time of a Pulſation, there goes out 80 Ounces in a third of a Minute, and conſequently the Velocity of the Blood is at leaſt thrice as great, or ſuch as will make it to move at the rate of 78 feet in a Minute; I have ſuppoſed that the Quantity of Blood that the Heart throws out every Syſtole is only one Ounce; becauſe that (being allowed of by all) gives the leaſt Velocity, and we are ſure it is at leaſt ſo much; but if every Syſtole throws out two Ounces, as many do ſuppoſe, then the Velocity is double to what it has been here determined, or the Blood moves at the rate of 156 feet in a Minute.

If the Sum of the Sections of the Branches of the Arteries were always equal to the Section of their Trunks, and if the Circuits in which the Blood moves were every where equal, the Velocity of the Blood would be every where the ſame it has been determined to be in the *Aorta*. But we find that the Sum of the Sections of the Branches do every where exceed the Section of their Trunks, and therefore the Velocity of the Blood muſt decreaſe upon this account, as the Number of Branches increaſe. Now let us ſuppoſe that the Sum of the Sections of the Branches, bears every where the ſame Proportion to their Trunks, and ſuppoſe A the Trunk of an Artery, and that at B it divides into two Branches, and the Branch B likewiſe into two at C, and that again into two at D, and ſo on: call A the Section of the Artery, the Sum of the Sections of Branches at B call B, and thoſe at C let them be named C, and thoſe at D E, and F, call alſo D, E

and F reſpectively. Let the Section of the Canal or Branch B C, be to the Section of



the two Branches at C, as A is to B. Likewiſe the Section of the Canal C D to the Section of the two Branches at D, as A to B, *&c.* Then the Velocity at A, will be to the Velocity at B, as B is to A, and the Velocity at B, will be to the Velocity at C as B is to A, and the Velocity at C, will be to the Velocity at D, as B is to A, *&c.* Let A repreſent the Velocity at A, then $\frac{A^2}{B}$ will repreſent the Velocity at B, and $\frac{A^3}{B^2}$ will be the Velocity at C; the Velocity at D will be $\frac{A^4}{B^3}$, that at E will be $\frac{A^5}{B^4}$, that at F will be $\frac{A^6}{B^5}$: And if the Artery be divided into a hundred ſuch Branches, before it come to the ſmalleſt, the Velocity at the laſt of them will be $\frac{A^{101}}{B^{100}}$, if into a thou-

ſand

ſand the Velocity at the laſt of theſe will be $\frac{A^{1001}}{B^{1000}} = A \times \frac{A^{1000}}{B^{1000}} =$ to the thouſandth Part of $\frac{A}{B}$ multiplied by A: The Velocity therefore at A, is to the Velocity after a thouſand branchings, as A is to $A \times \frac{A^{1000}}{B^{1000}}$, that is as 1 to $\frac{A^{1000}}{B^{1000}}$, or as 1 is to the thouſandth Power of $\frac{A}{B}$.

Thus if the ratio of A to B was known, the Velocity of the Blood at the ſeveral branchings of the Arteries might eaſily be determined; but this is only to be found by meaſuring of the Arteries; and by the Meaſures I have nicely taken from the Artery of the Thigh injected with Wax by Mr *Cowper*, I find the following Proportions.

Trunks	Branches	Branches	Branches
50625	44521	35344	
35344	15129	24649	
24649	22500	11236	5041
22500	10404	21316	
21316	18496	8836	
18496	11449	7056	2500
11449	8464	5776	
44521	9025	38809	
32761	3364	2116	31684
31684	5776	29584	
29584		26896	
26896	7396	27889	
7396	7056	3600	
7056	3844	4624	
38809	3600	29929	
29929	7744	7744	29241
29241	2809	1764	27225
21316	13689	12321	95691
5184	4096	4096	
4096	3600	3600	
3600	3969	4225	
4225	3025	3136	
507067	209956	314546	

By these Numbers it appears, that though the Ratio is not every where exactly the same, yet the difference is generally inconsiderable, and we may, without any notable Error, take the Ratio of the Trunks to the Branches to be as the Sum of these Trunks to the Sum of their

their Branches, which is as 500677 to 620193, or as 10000 to 12387, and then $\frac{A}{B}$ is 0.80729, whose Logarithm is 9.9070296. This Logarithm, multiplied by 30, gives the Logarithm of the thirtieth Power of 0.80729, which is 7.2108880, to which the Number answering in the Tables is 0.00162512; that is, the Velocity at A in any Artery is to the Velocity at its 30th branching, as 1 to 0.00162512, or as 100000000 to 162512, or as 615 to 1. The Logarithm of 0.80729 multiplied by 40 gives for the Logarithm of the Velocity at the 40th branching 6.2811840, to which the Number answering in the Tables is 0.000191066. Hence the Velocity of the Blood in the *Aorta* is to the Velocity at the 40th division as 1 to 0.000191066, or as 1000 000 000 to 191066, or as 5233 to 1. But if we suppose 50 series of divisions between the *Aorta*, and some of the smallest Capillaries or evanescent Arteries, the Log. 9.9070296 multiplied by 50 gives 5.3514800, whose Number is 0.000022463, and consequently the Velocity of the Blood at the Heart will be to the Velocity in the last evanescent Artery, as 1 to 0.000022463, or as 1000000000 to 22463, or as 44507 to 1.

Thus having shewn how the Velocity of the Blood may be determined at each branching of the Artery, our next Enquiry must be to find out how many times an Artery may divide before it becomes the smallest Capillary, which may be thus done.

Suppose the Ratio of the Trunk to the Branches to be as $r : s$, and call the Trunk c, then

then $r : s :: c : \frac{sc}{r}$, which is therefore the Sum of the two firſt Branches, and each Branch is $\frac{sc}{2r}$. Again $r : s :: \frac{sc}{2r} : \frac{s^2c}{2r^2}$. This is the Sum of the 2d branching, of which ½ is the Branch $= \frac{s^2 c}{4r^2}$; and juſt ſo the third Branch will be $= \frac{s^3 c}{8r^3} =$ to the Cube of $\frac{s}{2r}$ multiplied by c.

Now if we call the Number of branchings x, and $\frac{s}{2r} = d$, the laſt Branch will be $d^x c$. Let us ſuppoſe the ſmalleſt Artery has its Diameter $\frac{1}{100}$ part of a Hair's Breadth, and that the Diameter of a Hair is the $\frac{1}{200}$ part of an Inch, the Section of this Artery will be 0.000 000 00 25, which I ſhall call $= e$. Then we have this Equation $d^x c = e$, which expreſſed by Logarithms is $x \times$ Log. $d - 100\,x + 1000 = e + 100 -$ Log. c (for the Log. of the x power of d, is $x \times$ Log. $d - \overline{x - 1} \times$ Log. of Unity, or 100.) Hence $x = \frac{\text{Log. } e - \text{Log. } c}{\text{Log. } d - 100}$.

Now the Ratio between the Trunk and the Branches being as 10000 to 12387 :: $r : s$, the Logarithm of s divided by $2r$ is 9.7919361 Logarithm of d. The Logarithm of e is — 8.6020600, and ſuppoſing c equal to the Diameter of the *Aorta* equal to 0.5329 decimals of an Inch, its Log. is — 0.2733543, and the Logarithm of e *minus* the Logarithm of c is — 8.3287057; this divided by the Log. d—100, which is — 0.2080639, gives in the Quotient

40,

40, for the Number of diviſions between the greateſt and the ſmalleſt Artery; and conſequently the greateſt Velocity of the Blood will be to the leaſt, in the Proportion of 5233 to 1, or the Blood will move 5233 times ſlower in ſome of the Capillary Arteries than in the *Aorta.* Thus whilſt the Blood, in the remoteſt diviſion of the Arteries, moves one Foot, that in the *Aorta* moves 5233; now the Blood in the *Aorta* moving at the rate of 73 Feet in a Minute would run 5233 Feet in one Hour and ſeven Minutes; and therefore where the Blood moves the ſloweſt in the Arteries, its Motion is at the rate of a Foot in one Hour and ſeven Minutes.

As between the greateſt and the leaſt Velocity we are to conceive all the intermediate Degrees; ſo we are not to imagine that in every evaneſcent Artery there is the leaſt Velocity, but only in ſuch as have at leaſt 40 diviſions between them and the great Artery; and the Velocity of the Blood in the evaneſcent Arteries is every where proportionable to the Number of diviſions between them and the great Artery; and therefore in all the ſmall Arteries which come immediately from the *Aorta*, and which after a few diviſions tranſmit their Fluid to the Veins, the Velocity of the Blood is but a little diminiſhed.

From all this it appears that when the whole Maſs of Blood is to be altered, that the Courſe of Phyſic ought to be continued for a long Space of time, being the Blood moves ſlower and ſlower the farther it moves from a great Artery, and conſequently it muſt be a great time before the whole Maſs of Blood can be

mixt with the alterative Medicine. And being the Circulation of the Blood thro' Glands which receive Arteries immediately from a great Veſſel, is very quick, they may carry off a great Proportion of the Medicine in a very little time, and therefore it is not the taking of great Quantities, but a conſtant taking that can alter the Maſs of Blood; and from hence it follows that when the Blood is to be altered by Mineral Waters, which are apt to paſs through the Glands of the Kidnies, that they ought not to be drunk in large Quantities: For if they paſs off, they have not the deſigned Effect; and if they do not, being drunk in a little time, they mix but with a ſmall Quantity of Blood, which muſt diſorder the Animal Œconomy.

ESSAYS ON SEVERAL PARTS OF THE Animal Oeconomy.

ESSAY III.

Of the Force of the Heart in driving the Blood through the whole Body.

THERE is not any Problem in the animal Oeconomy, which appears to be of greater difficulty than that about the force of the Heart. And the Labour and Pains *Borelli* has taken in 11 Propoſitions to determine it, do only demonſtrate that the method he uſed was extremely intricate, and his determination of its being equal to more than 135000 ℔ weight is paſt all credibility. So much Geometry employed to ſo little purpoſe, by ſo great a Man, has undoubtedly deterred

deterred others from attempting it. But I hope to make it appear that a very little Geometry, rightly made uſe of, will eaſily determine this ſeemingly very intricate Problem.

If we have the Velocity wherewith a Fluid flows out at any Orifice without any reſiſtance from an anterior Fluid, it is eaſy to determine the force which produces that Motion. For let the Line A B be the Height from which if a Body fall, it will acquire a Velocity equal to the Velocity wherewith the Fluid flows out from the Orifice; then is the force which produces this Motion of the Fluid equal to the Weight of a Cylinder of the ſame Fluid, whoſe Baſe is equal to the Orifice, and whoſe Height is equal to 2 A B, by the 2d Corol. of 36 Prop. of the 2d Book of *Newton*'s *Principia.*

Now the Blood flowing out of the Heart, is much reſiſted in its Motion by the anterior Blood in the Arteries and Veins, and therefore cannot flow with all the Velocity the force of the Heart would give it, were there no ſuch reſiſtance, ſome part of that force being ſpent in overcoming the reſiſtance which ariſes from the reſt of the Maſs of Blood. If therefore we could know how much the Velocity of the Blood is diminiſhed by this reſiſtance, or what Proportion the Velocity of Blood reſiſted, has to the Blood that is driven out, and not reſiſted; having already determined the Velocity of the Blood as it is reſiſted, we might eaſily from thence collect the Velocity by which the Blood would flow were it not reſiſted; and from thence the abſolute Force of the Heart. To find out this, I

made

made the following Experiment; for to proceed entirely upon Speculation in ſolving of any *Phænomenon* of Nature, is certainly wrong, but an Obſervation or Experiment carefully made and duly applied, eaſes us of a great deal of trouble and leads us with greater Certainty to the Solution we want to know.

Having uncovered the *Iliack* Artery and Vein in the Thigh of a Dog near to his Body, and having paſſed convenient Ligatures under them, I opened the Vein the whole Diameter of the Veſſel, and received into a Cup all the Blood which run from it for the Space of ten ſeconds of a Minute; after that, I did the ſame by the Artery for the ſame ſpace of time, and had both the Quantities of Blood carefully weighed. There is no Experiment how eaſy ſoever, but what is attended with Circumſtances, of which one is not always aware, eſpecially at the firſt tryal, and which may very much alter the ſucceſs of the Experiment, and therefore I had this Experiment repeated ſeveral times, and did find by them, that the Quantity of Blood which run from the Artery was to the Quantity which run from the Vein, in the ſame ſpace of time, nearly as $7\frac{1}{2}$ to 3. Now the Velocity of the Blood in the Iliack Artery ſo near to the Aorta, is nearly the ſame with that in the Aorta, and conſequently the Velocity with which it flows out of the Iliack Artery cut aſunder, is the ſame with which it would flow out of the Heart unreſiſted, or the Blood runs through a Wound in the Iliack Artery with all the Velocity it receives from the Heart. Now all the Blood which runs along the Iliack Artery, returns again by

by the Iliack Vein; and consequently the Quantities of Blood which pass through both in the same space of time are equal. The Quantity of Blood therefore which run out of the Iliack Vein cut asunder, is the same which run through the Iliack Artery before it was cut, in the same space of time. Having therefore the Quantity which runs through the Iliack Artery, when it is cut, and when it is not cut, we have their Velocities; for the Velocity of any Fluid running through the same Canal in equal spaces of time, is directly as the Quantities: But the Velocity of the Blood when the Artery is cut, is equal to that it receives by the full force of the Heart; and the Velocity, when it is not cut, is that Velocity with which the Blood moves through the Aorta resisted by the anterior Blood, and therefore these two Velocities are to one another as $7\frac{1}{2}$ to 3.

Now if the Heart throws out 2 Ounces of Blood every Systole (as is most probable) then the Blood moves through the Aorta at the rate of 156 Feet in a Minute, as has been already computed; and therefore the absolute Velocity wherewith the Blood would be forced into the Aorta, did it find no resistance, is such as would make it to move 390 Feet in a Minute, which is near $6\frac{1}{2}$ Feet in a $''$ of time. We must next enquire, what is the Height, from which if a Body falls, it will acquire this given Velocity; for this Height doubled gives the length of the Cylinder, whose Base is equal to the Orifice of the Aorta, and whose Weight is equal to the absolute Force of the Heart.

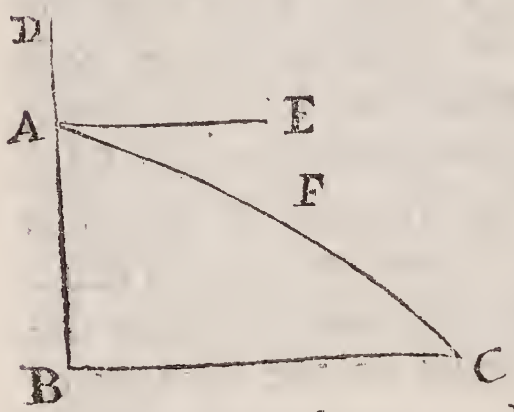
It

It is known by Experiment that the Force of Gravity, will make a Body move 30 Feet in a second, which is the Velocity it acquires in falling through 15 Feet; and therefore this Velocity is to the Velocity of the Blood flowing without resistance into the Aorta, as 30 to 6.5. But by the Doctrine of *Galileo*, the Heights from which Bodies acquire given Velocities, are as the Squares of the Velocities, that is as 900 to 42.25; therefore as 900 to 42.25 so is 15 to 0.74. This Height doubled gives the 1.48 or in Inches 17.76, which is the Height of a Cylinder of Blood, whose Base is equal to the Aorta, which we have supposed to be equal to 0.4187; and therefore the solid Content is 7.436112, the Weight of which is equal to the absolute Force of the Heart. This Weight is five Ounces, and therefore the Force of the Heart is equal to the Weight of five Ounces.

Thus we see how vastly short this Force falls of that determined by *Borelli*. The method and reasonings we have used are certainly just; all that can be objected is, that perhaps our Experiments upon which the demonstration is founded were not so nice as they ought to have been, tho' they were repeated several times. But let us suppose the Velocities of the Blood resisted and not resisted in the Aorta, are not to one another as 3 to $7\frac{1}{2}$; but as 3 to 15, and undoubtedly the Error of the Experiment cannot possibly be so great as to make so great a difference: Then if we calculate upon this *ratio*, we shall find that the Force of the Heart is little above 16 Ounces.

But the Force of the Heart may be found a ſtill more eaſy and ſimple way, thus. It is demonſtrated by the Writers of Mechanicks, that if a Body whether fluid, or ſolid, be projected from any Height, according to a horizontal Direction, it will deſcribe by its Motion a *Parabola* whoſe *Latus Rectum*, is equal to four times the Height, from which a Body muſt fall to acquire the Velocity wherewith it is at firſt projected.

Having therefore opened the Iliack Artery



of a Dog, laid in the horizontal Direction AE, and 28 inches high from the Ground: I found that the Blood moving in the *Parabola* A F C, touched the Ground at C, which was about 3 Feet diſtant from the perpendicular A B let fall from the Heart. Now if A D be taken equal to $\frac{1}{4}$ of the *Latus Rectum* of the *Parabola*, it will be the Height from which the Blood muſt fall to acquire its Velocity at A. And becauſe from the Nature of a *Parabola*, the Rectangle under the *Latus Rectum*, and the Altitude AB is equal to the Square of B C; that is $4\ AD \times AB = Bcq$, or $AD \times AB = \frac{1}{4}\ Bcq$: therefore $AB : \frac{1}{2}\ BC :: \frac{1}{2}\ BC : AD$, that is $28 : 18 :: 18 : 11.5$. $11\frac{1}{2}$ inches is therefore the Height the Blood muſt fall from to acquire the Velocity wherewith it is projected by the Heart. But this Height doubled gives the length of a Cylinder, whoſe Baſe is equal to the Orifice of the Aorta, and whoſe Weight is equel to the abſolute

abſolute Force of the Heart: The length of the Cylinder is therefore 23 Inches. The Orifice of the Aorta of this Dog, I found to be .096 and therefore the ſolid Content of this Cylinder is 2.208, which is equal to one Ounce and the third part of an Ounce, equal to the Force of this Dog's Heart. Now the Heart of this Dog weighed two Ounces, and if we ſuppoſe the Strength of two Hearts to be to one another as their Weights, (which we reaſonably may, the Structure and Fabrick in both being alike) and that the Weight of an ordinary human Heart is 12 Ounces, then the Force of ſuch a Heart, will be equal to almoſt 8 Ounces Weight. So that though this is ſomething more than what was determined before; yet it is very inconſiderable, and of no moment in reſpect of what the Force of the Heart was commonly imagined to be.

After this method the Force of the urinary Bladder may certainly be determined: For ſuppoſe the Bladder 3 Feet from the Ground, and that it throws out the Urine in a horizontal Direction 6 Feet: Then the Height from which it muſt fall to acquire the Velocity by which it is thrown out from the Bladder, will be 3 Feet, and this Height doubled is the Length of a Cylinder, whoſe Baſe is equal to a tranſverſe Section of the *Urethra*, (the Diameter of which Section I take to be about $\frac{2}{10}$ parts of an Inch) and whoſe Weight is the Force of the Bladder. Now the Weight of ſuch a Cylinder will be found to be near 3 Ounces, which is therefore the Force of the Bladder in throwing the Urine 6 Feet forwards.

Borelli required a Force in the Heart equal to the preſſure of 180000 ℔ weight, to move 20 ℔ weight of Blood, whereas from what has been demonſtrated, above 100 ℔ weight of Blood may be moved by a Force in the Heart which does not exceed the preſſure of one Pound at moſt. This may to ſome ſeem very ſtrange at firſt ſight; but if we conſider the Caſe attentively, this Force in the Heart will be found ſufficient for all that is required of it. It is not indeed requiſite that the Force of the Heart ſhould be able move 100 ℔ of Blood at reſt; but this Blood being once moved, the Force of the Heart muſt be ſuch as will preſerve the Motion at firſt communicated to the Blood: How the Blood came firſt by its Motion, is not my preſent Enquiry, that I leave to be determined by the occult Philoſophers: However this is certain, that if the reſiſtance of the Blood bore always the ſame Proportion to the Force of the Heart that it does now, that the Blood never could at firſt be put in Motion by the Heart. Now did the Blood conſtantly move forwards, with the Motion at firſt communicated to it, and did the Coats of the Veſſels make no reſiſtance, the poſterior Blood would not be retarded by the anterior, and the Motion of the Blood would equal the entire Force of the Mover. But becauſe of the reſiſtance made by the Coats of the Blood-Veſſels, and the Force which is ſpent in diſtending of them, the Blood is conſtantly retarded in its Motion as it circulates, and would in a ſhort time ſtop, were not the Motion loſt made up by a freſh impulſe from the Heart; and there-

fore

fore the Force of the Heart muſt be equal to the reſiſtances the Blood meets with in its Motion; if it were more, the Velocity of the Blood would be continually increaſing; if leſs, it would continually decreaſe, and at laſt ſtop. And from hence it is evident, that if the Circulation of the Blood were once ſtopt, all the Force of the Heart could never ſet it a moving again.

A
DISSERTATION
CONCERNING THE
Force of the HEART,

By JAMES JURIN, *M. D. F. R. S.*

To the Learned RICHARD MEAD, *M. D.*

SIR,

Philos. Trans. num. 358. *pag.* 863.

THOUGH I am not ignorant, how rude and imperfect this Dissertation is, yet I readily venture to submit it to your penetrating judgment. For how could I wish for a more impartial Judge, or how could I choose a more proper Umpire, than him, whose remarkable Candour and Humanity are as well known to us all, as those excellent talents which he enjoys, adorned with every kind of Learning; and by whose bright Genius and fine Judgment we see the Theory of Medicine enlightened and illustrated, and the Practice of it strengthened and made easy? Nor is there any one living, of whose approbation I should be more desirous, or under whose authority this discourse, if it has the good

good fortune not to displease you, will be more safe from the Cavils of some perverse people. Of whom some being led by Prejudice, and by the Reputation of great Names, whose Opinions I shall here controvert, will perhaps not think it worth the while to examine or read what I have said. Others, to avoid either the trouble of learning, or owning their ignorance, will give themselves an Air of despising what they do not understand. As I will readily grant them, that there were formerly and are now several learned Men, who, without being acquainted with Mathematical Knowledge, exercise the Art of Healing with Success and Reputation; on the other side they cannot but allow, that the Mathematics are not useless in Practice, but absolutely necessary in discovering the nature and causes of Diseases. For, as you very well know, since the bodies of Animals consist partly of solid Canals, partly of Fluids which continually pass thro' them, it plainly appears that they are Machines, and therefore that the knowledge of Mechanicks is necessary to understand their Fabrick, Forces, Actions, and Impediments of Action, or Diseases.

Which subjects have been treated even by Mathematical Writers, after Methods so inaccurate, and so contradictory to each other, and to Reason, that they have not only added no esteem and honour to the most noble of Sciences, but have even laid it open to the contempt and ridicule of the unlearned. For who, that is not himself a Mathematician, when he sees, for example, that the force of the human Heart is sometimes made equal to

3,000 ℔ weight, sometimes made to exceed 180,000, and sometimes brought down to five or eight ounces; that the Air also is driven out of the Lungs in Exspiration by a force, sometimes of 100 sometimes of 50,000 ℔; who, I say, that has read these conclusions so enormously different, and yet all supported by demonstrations, if he can forbear laughing, does not at least pronounce the knowledege of Mechanics of no use to discover the faculties of the Body? But proper judges will think it no wonder, if sometimes, in a difficult Problem, even the ablest heads mistake, and will know that, if any mistakes appear, they are not to be imputed to the Art, but to the Artist. To shew this more plainly by an example, I shall propose a new solution of the famous Problem concerning the Force of the Heart. And, to avoid the imputation of rashness in attempting this after the famous *Borelli*, and to pave a way for the reader to determine justly and certainly, in so great a dissension of authors, I shall shew in the first place the errors of *Borelli*'s Demonstration, and shall then, with the same freedom of inquiry, examine the solutions of *Morland* and *Keill*.

The first and principal fault of *Borelli*'s solution seems to be, that he explains the Power of the Heart by a dead and unactive weight. For, as the Heart it self is moved, when it contracts, and, as it impels the opposite bodies, the Blood and Coats of the Arteries, into motion, it is plain that there is no other way of discovering how great it's power is, than by finding out the quantity of this motion. But it is as impossible to compare any motion with a Quies-

a Quiescent weight, as a line with a Rectangle.

The second error is, that in the very experiment made by the Circulator, it does not at all appear that the weight was suspended solely by the contractile force of the Muscles; since that force also, by which the Muscles applied, and the cheeks also, and perhaps even the Ligaments might hinder their own divulsion and the Rupture of the Fibres, and by which even Muscles cut out of a dead body sustain considerable weights, might give some assistance.

3. That the forces of Muscles of equal weight are reckoned equal by *Borelli*: which seems to be very doubtful, especially when the Muscles are of different figures.

4. That he applies the whole power of the Heart, that can be exerted by the greatest Force and endeavour of the Fibres, to each Systole. Whereas the Circulator it self, if it was to strive to raise a suspended weight, either continually, or alternatly with the interposition of a very short rest, must soon fall under the attempt.

5. That he makes the resistance of the Blood and Arteries to be sixty times as much as the whole Power of the Heart, instead of it's power in making the Systole, which perhaps is the least part of the whole power.

6. That he has committed a great error in defining that sixty-fold Ratio. For in Prop. 60, instead of the Ratio of the Sum of the Powers P and Q to the Sum R and S, he has given the Ratio, between the Rectangle of the Powers P, Q, and the Rectangle of R, S. If which error

error be corrected by the subsequent Propositions, the resistance will be found much greater in Prop. 73, than it is determined by *Borelli* himself, namely a weight of 1,076,000 ℔ instead of 180,000 ℔, and that according to the positions laid down by the Learned author himself.

7. Lastly, That he obtrudes upon the Reader the weight of 180,000 ℔ when it is exceeded by a Power of the Heart equal to 3,000 ℔ as some Miracle or Monster, and calls the force of a Percussion to his assistance, like some Θεὸς ἀπὸ μηχανῆς. For in reality there is no other prodigy in it, than that a weight of 3,000 ℔ should keep *in equilibrio* another weight of 180,000 ℔ hung at almost a sixtyfold distance from the centre of a balance of unequal *radii*.

I choose to pass over some smaller slips, many arbitrary *Hypotheses*, and some that contradict others. And the faults which I have already shewn, or at least the greater part of them, may perhaps not so much deserve to be imputed to that learned Author, as to the Work's being posthumous.

The next that follows is the Learned Dr *Joseph Morland*, who in his Inquiries into the Force of the Heart, has proposed a very ingenious method of trying the Power of the Heart. But besides the error just now reprehended in *Borelli*, of comparing the Force of the Heart to a quiescent weight, he seems to have erred also in making the whole action of the Heart to be employed in distending the coats of the Arteries. For the Heart not only extends the Arteries, but also drives the

Blood with a certain Velocity thro' the whole courſe of the Arteries and Veins.

In the laſt place I ſhall weigh the Solution of the very ingenious Dr *James Keill* in his *Eſſays on ſeveral part of the Animal Œconomy*, lately publiſhed. Who firſt of all ventured not only to reject the Power of the Heart, as it was determined by *Borelli*, and received and applauded by a great number of Writers, but alſo to ſubſtitute another in the room of it, almoſt infinitely leſs.

He ſeems to me to have erred, not only in falling into the firſt miſtake of *Borelli*'s Solution, but alſo in the following particulars.

That he either miſunderſtood, or at leaſt made an improper uſe of that Corollary of Sir *Iſaac Newton*, from which he endeavours to determine the Force of the Heart. For the weight determined by our *Britiſh Archimedes*, by which the motion of Water flowing out of a Veſſel may be generated, does not generate the motion of the Water; which acquires it's own motion by falling by the Force of it's gravity. But this weight by falling for a given time, acquires a motion equal to the motion of the flowing Water in the ſame given time.

Beſides this learned Author always ſuppoſes the Velocity of Blood flowing out of the Heart to be equal thro' the whole duration of the Syſtole, which I ſhall ſhew to be very unequal, in what follows.

In the more ſimple way, which the learned Author afterwards propoſes, beſides the foregoing errors there are two others.

For he supposes the strength of the Hearts of different animals to be to one another as their weights, which I shall shew to be false. He also supposes the velocity of the Blood flowing out of the Iliack Artery cut asunder, to be the same as that with which it is thrown out of the Heart into the Aorta. But as almost all the Blood that is driven out of the Heart is let out by the other Iliack Artery cut asunder, it appears that it's Velocity is so much greater in the Iliack Artery than in the Aorta, as a circular section of the Iliack Artery is exceeded by a section of the Aorta. Besides that the equable Velocity, with which the Blood flows thro' the Aorta, is very different from that Velocity, with which it comes out of the Heart.

In like manner may that method be rejected, which the learned Author uses to determine the Ratio between the different Velocities of the Blood, flowing thro' the Aorta, with and without resistance. But as by that Experiment not one only, but both Velocities are found too great, whence the Ratio that is between them is not greatly perverted, the proportion laid down by him may be well enough received, as not being far from the truth.

Having proceeded thus far, and discovered the rocks on which these great men have split, we must now proceed with the greatest caution in so difficult a passage, and so full of errors. And in the first place, to avoid ambiguity, it is necessary to define a little more accurately what is the subject of our inquiry.

By the Force or Power of the Heart we mean either the motion itself of the Heart, whilst

whilst it is made to contract, or the motion of any weight, which being opposed to the Blood, as it rushes out of the Heart, and brought against it with a proper Velocity, can ballance and stop the efflux of the Blood, and consequently the very contraction of the Heart.

As we can hardly hope to determine that Power *à priori*, because we neither sufficiently know the internal structure of the Heart, nor the nature of it's contracting cause, it remains to judge of it by the effects, or *à posteriori.*

The whole action of the Heart consists in the contraction of it's Ventricles. Now the Ventricles, when they contract, impinge upon the Blood, and, by communicating to it some part of their own motion, urge and expel it with great Force, *qua data porta.* The Blood thus protruded into the Aorta and pulmonary Artery, pressing on all sides impinges partly on the Coats of the Arteries which were relaxed and flaccid at the preceding Systole, partly on the preceding Blood flowing more slow. Whence the Coats of the Arteries are gradually thrust outwards, and the course of the antecedent Blood is quickened. But if we imagine the Arteries to be divided by minute transverse Sections, when the first little portion of Blood rushes into the first Section, partly that Section is distended, partly the Blood contained in it before is thrust down into the next Section, and distends it, and that action is continued thro' the succeeding Sections of the Arteries. And then the second, and third little portion of Blood, and so the rest one after another into the first Section of the

Artery, and dilate it a little more, and propel the Blood contained in it into the next Sections successively; and so on till all the Blood is thrown out of the Ventricles. But it must be observed that the more contracted and flaccid the Arteries are, the less they resist the dilatation, and the more they are dilated, the stronger they resist any farther distraction; and therefore that the Force of the Blood bursting out of the Heart is at first more spent upon the distention of the Arteries, than upon the protrusion of the preceding Blood, but at last that the antecedent Blood is more propelled than the Arteries are distended, for being now made stiff they scarce admit a greater dilatation.

But as the Blood rushing out of the Heart, as was before observed, communicates part of it's motion to the Coats of the Arteries, part to the preceding Blood, it must necessarily abate something of it's former swiftness, and therefore whilst it delays the contraction of the Ventricles, it receives a new impulse from them and bestows part of it, for the same reason as was given before, on the Coats of the Arteries, and the preceding Blood, whence it is again retarded, and receives another stroke of the Ventricles, and so on, till it is all driven out of the Ventricles.

Besides the cause assigned above, there remains another, by which the Blood flowing out of the Heart is gradually retarded, and so successively receives new *impetus*'s from the Ventricles contracting themselves. For the Blood flowing into the Aorta, tho' it be supposed to meet with no resistance at all, and so

to ſuffer no diminution of it's motion, yet as it is carried from a wider into a narrower compaſs, it increaſes continually in length, till it is all come into the Aorta; and as the Section of the Aorta is not diminiſhed, the Velocity of the Blood is neceſſarily diminiſhed. For the motion of the Blood is in a Ratio compounded of the Ratio of a Section of the Aorta, of the Velocity in it, and of the length of a column of Blood, by our third Theorem *De Motu Aquarum fluentium.* But as the portion of Blood, which is already come into the Aorta, is gradually retarded, the Blood contained in the Ventricle will be thereby retarded, and hence the contraction alſo of the Ventricle will be retarded. Whence the Ventricles will continually communicate one part of their motion after another to the contiguous Blood, continually retarded by the ſame cauſes. I ſhall obſerve by the by, that it appears from hence, that the Blood has one motion when it is burſting out of the Heart, and another when it is already driven out of the Heart, and flowing in the Arteries. Alſo that the ſtroke or impulſe of the Ventricles upon the Blood, which otherwiſe would be ſingle, and performed in an inſtant, is continued thro' the whole Syſtole, by the Force of the above mentioned cauſes, by which the Blood is continually retarded.

Let us therefore conſider each Ventricle of the Heart driving the Blood as a given body impinging with a given ſwiftneſs on another body at reſt, to which part of it's motion being communicated, both bodies are carried with a common Velocity. But the power of it is

equal

equal either to the *Factum* of the weight of the Ventricle, and its initial Velocity, before it impinges on the Blood; or to the sum of the motions of the Ventricle it self and the Blood flowing out of it, and of the motion which is communicated to the Coats of the Arteries, and to the preceding Blood; or, if we suppose no resistance of the Arteries and preceding Blood, to the Sum of the motions of the Ventricle, and of the effluent Blood.

Theorem I.

The motion, by which a hollow Machine unequally contractile is caused to contract, is equal to the Sum of the Facta *of every particle of the Machine, drawn into their respective Velocities.*

It appears from Mechanicks.

Corol. I. The motion of a Machine is less than the *Factum* drawn from the weight of the Machine into the Velocity of those parts of the Machine, which are moved with the greatest swiftness whilst they contract.

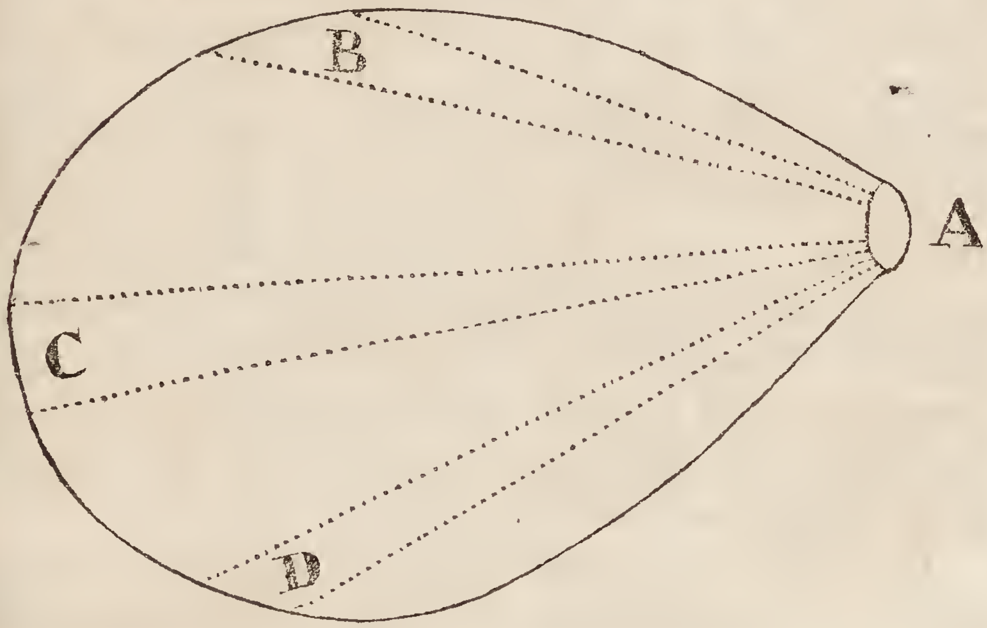
II. The motion of a Machine is equalled to the *Factum* of it's weight drawn into some middle Velocity between the Velocities of those parts of the Machine which are moved most swiftly, and those which are moved most slowly.

III. If several similar Machines contract themselves in like manner, the middle Velocity, either equable or inequable, yet being in like manner augmented or diminished in all the Machines, the motion, by which each Machine

Machine is caused to contract, obtains a Ratio compounded of the Quadruplicate Ratio of the Homologous Diameter of the Machine, and the inverted Ratio of the time, in which the contraction of the Machine is performed, or a Ratio compounded of the Ratio of the weight of the Machine, the Subtriplicate Ratio of the same weight, and the inverted Ratio of the time.

Theorem II.

If water be pressed out of a hollow Machine unequally contractile, ABCD, *by the contraction of the Machine, the motion of the Water, coming out of the Orifice* A *is equalled to the Sum of* *Philos. Transact. num.* 359. *pag.* 929.



the Facta *of any transverse Sections of all the filaments of water* AB, AC, AD; *each being drawn into their respective Lengths and Velocities.*

Demonstration. Instead of the Filaments of Water, let a Machine he conceived to consist entirely of very small Tubes, of unequal size, A B, A C, A D, ending in the Orifice A.

The Motion of Water in any Tube is equal to any Section of the same Tube, drawn into the Velocity of the Water flowing thro' that Section, and the length of the Tube, by *Theor. III. De Motu Aquar. fluent.* Therefore the Sum of the Motions of the Water in all the Tubes taken together, or the Motion of the Water bursting out of the Orifice of the Machine is equal to the Sum of the *Facta* of the Sections of all the Tubes or Filaments of Water, drawn into their respective Lengths and Velocities. *Q. E. D.*

Corol. I. The Motion of Water flowing out is less than the *Factum* of the Orifice A, the Velocity of the Water going out, and the length of the longest filament of Water. For the *Factum* of the Orifice and of the Velocity of the effluent Water is equal to the Sum of the *Facta* of each of the Sections of the filaments, drawn into their respective Velocities; and the Sum of these *Facta* drawn into the length of the longest filament is greater than the Sum of the same drawn each into their own length.

II. The Motion of Water is equalled to the *Factum* of the Orifice A, and of the Velocity of the Water going out, drawn into any middle length between the lengths of the longest and shortest filaments: or is equalled to the *Factum* of the quantity of Water flowing out in a given time, and of the middle length beforementioned, applied to that given time.

III. If

III. If ſeveral ſimilar Machines full of Water be in like manner contracted either with an equable or unequable middle Velocity, but alike increaſed or diminiſhed in all the Machines; the Motion with which the Water burſts out of the Orifice of each Machine, has a Ratio compounded of a Quadruplicate Ratio of every Homologous Diameter of the Machine, and a reciprocal Ratio of the time, in which the Contraction of the Machine is performed: or a Ratio compounded of the Ratio of the weight of the Machine, or bulk of water, either contained in the Machine, or driven out of it, a Subtriplicate Ratio of the ſame weight or bulk, and a reciprocal Ratio of the time.

PROBLEM.

To find the Power of the Heart.

Make $p =$ the Weight of the left Ventricle, or the quantity of Blood equal to the ſame Weight.

$S =$ internal Superficies of the ſame.

$l =$ middle length of the filaments of Blood coming out of it.

$s =$ a Section of the Aorta.

$q =$ the Quantity of Blood contained in the left Ventricle.

$t =$ the Time, in which the Blood would be driven out of the Heart, if the reſiſtance of the Arteries and preceding Blood was taken away.

$v =$ the variable Velocity, with which the Blood ruſhing out of the Heart

would flow thro' the Aorta, if the resistance was taken away.

$x =$ The variable length of the Aorta which is run thro' by the Blood flowing out of the Heart.

$z =$ the time, in which the length x is run thro'.

Thence the variable middle Velocity of the Blood contiguous to the Ventricle, or the middle Velocity of the Ventricle itself $= \frac{s v}{S}$.

The Motion of the Ventricle (by Theor. I. Cor. II.) $= p \times \frac{s v}{S}$.

The Motion of the effluent Blood (by Theor. II. Cor. II.) $= s\, v \times \overline{l + x}$.

The Sum of these, or the Power of the Ventricle $= s\, v \times \overline{\frac{p}{S} + l + x}$. But v is $= \frac{\dot{x}}{\dot{z}}$.

Whence by the Newtonian method inverted, we find the power of the Ventricle $= \frac{s x}{z} \times \frac{p}{S} + \frac{x}{2} + l$. But as $z = t$, so $s x = q$.

Hence the Power of the Ventricle is $= \frac{q}{t} \times \frac{p}{S} + \frac{q}{2 s} + l$.

In like manner the Power of the right Ventricle is found $= \frac{q}{t} \times \frac{\pi}{\Sigma} + \frac{q}{2 \sigma} + \lambda$.

The

The ſame is ſignified by Greek Letters in the right Ventricle, as by Latin letters in the left. Hence the whole Power of the Heart

$$= \frac{q}{t} \times \overline{\frac{p}{S} + \frac{\pi}{\Sigma} + \frac{q}{2s} + \frac{q}{2\sigma} + l + \lambda}\text{. Q.E.I.}$$

If we ſuppoſe,

$p = 8$ ounces Avoird. $= 13.128$ Cub. inches
$\pi = 4$ $= 6.564$
$S = 10$ ſquare inches
$\Sigma = 10$
$l = 2$ inches
$\lambda = 1\frac{1}{2}$
$q = 2$ ounces Avoird. $= 3.282$ cub. inches
$s = 0.4185$ ſquare inches
$\sigma = 0.583$
$t = 0''.1$

By Dr *Keill*'s Experiments.

The Power of the Ventricles will be equal to the following weights:

	℔	℥
Of the left Ventricle — — —	9	1
Of the right Ventricle — — —	6	3
Of the whole Heart — — —	15	4

Of which weights the Velocity is that, with which the length of an inch is run in every Second.

Cor. I. As often as the Pulſe becomes quicker; either the reſiſtance is leſſened, or the Power of the Heart is increaſed, or a leſs quantity of Blood than uſual is thrown out of the Heart at each contraction.

II. If the Pulſe is ſlower than uſual, it is evident, either that the reſiſtance is increaſed, or the Power of the Heart leſſened, or that a greater

greater quantity of Blood is thrown out of the Heart.

III. If the resistance is increased, it will necessary follow, either that the Pulse will be retarded, or the Power of the Heart increased, or that a less quantity of Blood than usual will be driven out of the Heart.

IV. If the resistance is lessened, either the Pulse is quickened, or a greater quantity of Blood is thrown out at each Systole, or the Force of the Heart is diminished.

V. If the Force of the Heart is increased, either the ressistance must necessarily be increased, or the Pulse quickened, or more Blood thrown out of the Heart.

VI. If the Force of the Heart is lessened, either the resistance must necessarily be lessened, or the Pulse grow slower, or less Blood be thrown out of the Heart.

VII. When a less quantity of Blood is thrown out of the Heart; either the Pulse is quickened, or the Force of the Heart diminished, or the resistance increased.

VIII. When more Blood is thrown out of the Heart; either the Pulse will become slower, or the Power of the Heart will be increased, or the resistance will be lessened.

Schol. I. Since it seems very difficult to determine accurately the internal Superficies of the Ventricles, or to give an account of the diminution, which they suffer in contracting, we have been content to estimate them by guess: for if you make each of them equal to 12, or to 8 square inches, it will make very little alteration in their Power. Which may also be observed of the middle length of the Filaments

Filaments of Blood. We alſo paſs over the differences of the Section by which both the Arteries, and their branches neareſt the Heart are increaſed, as very difficult to be diſcovered, and almoſt inſenſible. Otherwiſe the Power of the Heart would appear to be a little leſs than we have eſtimated it.

II. The learned Dr *Keill* has determined the Velocity of the Blood flowing out of the Heart, without reſiſtance, is ſuch as would make it to move near $6\frac{1}{2}$ feet in a $''$ of time. But he ſuppoſes the ſwiftneſs of the Blood to be equable thro' the whole Syſtole, which we have ſhewn already to be very unequal, and to be retarded gradually from the beginning of the Syſtole. If any one would determine this, he muſt ſubſtitute the Power of the Ventricle found in the fourth Equation above, and aſcribe ſome value to x, to extract v, or the Velocity reſponding to it. Thus, as in the beginning of the Syſtole $x = o$, and at the end $x = \frac{q}{s}$ the Velocity of the Blood at the beginning of the Syſtole, is determined to be ſuch as to flow $14\frac{1}{4}$ feet in a ſecond; but at the end to flow $4\frac{1}{2}$ feet in a ſecond. In like manner in the right Venticle: the beginning Velocity of the Blood will make about $10\frac{5}{6}$ Feet, but the laſt 3 feet in the ſame ſpace of time.

Hitherto we have made uſe of that Hypotheſis, in which the Muſcles conſtituting the Ventricles of the Heart receive all the Motion, by which they are cauſed to contract, in a moment of time. But if we ſuppoſe the Motion not to be communicated to them in a ſingle

moment, but in a very ſmall ſpace of time, which bears but a ſmall proportion to the whole duration of the Syſtole; the Power of the Heart muſt be eſtimated ſomething greater, than we have determined it. But if that Motion be eſtimated, during the Syſtole, to be increaſed in proportion to the time; the whole Motion acquired in the end of the Syſtole will be twice as great as we have ſuppoſed it, if the Blood flowing out of the Heart meets with no reſiſtance. But when there is the uſual reſiſtance, it will be five times as great, which will appear by the calculation. In like manner our calculation may be accommodated to any other Hypotheſis, by which the Motion of the Ventricles may be augmented in a duplicate or other larger proportion of time. But the Power acquired at the end will be found far greater than what was ſuppoſed above, namely triple by a duplicate, quadruple by a triplicate, quintuple by a quadruplicate Ratio, and ſo on *in infinitum*.

But the ſecond Hypotheſis, by which the Ventricles receive all their Motion in a very ſhort ſpace of time, ſeems to me much the moſt probable. As ſome time muſt be ſpent in generating any Motion; and as the Motion of the Ventricles does not ſeem to increaſe ſo ſlowly, as not to be augmented quicker, than according to the Ratio of the time. For the Motion of the Muſcles cannot be cauſed merely by the *impetus* of any Fluids, which come out of the Blood; ſeeing we can exert a Motion with either arm, far greater than the Motion of the Blood flowing thro' all the Veſſels of the Body. It remains therefore, that

that the Fibres of the Mufcles compofing the Ventricles of the Heart be impelled into Motion by fome Rarefaction of the Liquors flowing into them. But this, as often as it requires a great Force, is commonly fudden, and almoft inftantaneous. Add to this, that the Motion of the Ventricles according to this Hypothefis is made much lefs, than by the third.

But which Hypothefis fo ever of thefe be admitted, all our Corollaries may alike be deduced from the Problem. Which, whether they will give any help towards explaining the Hiftory of Difeafes, we leave to the confideration of the Sagacious Phyfician. But it may eafily be known, by the nature of every Difeafe, whether the refiftance be increafed or diminifhed. It is probable alfo that the Force of the Heart may be increafed or leffened, as the Force of the other Mufcles is augmented or diminifhed; tho' I find the celebrated *Bellini* has determined otherwife.

Theorem. III.

The whole Motion of the refiftance, which hinders the Blood burfting out of the Heart, during the Syftole, or the whole Motion, which is communicated to the preceding Blood, and to the Coats of the Arteries, is very nearly equal to the whole Power of the Heart.

Dem. When the Syftole of the Heart is finifhed, that part of the Aorta and Pulmonary Artery, which is next the Heart, remains full of Blood thro' the whole Syftole of the Arteries. For their Fabrick and Juncture, by

by which they are United to the Heart, does not suffer them to be entirely closed by the Coats perfectly falling close to one another, nor can their cavity be void of Blood. For otherwise, when the other parts of the Arteries contract themselves, the Blood contained in them would be driven into a Vacuum with a Motion that is backward, and useless and contrary to the natural Motion of the Blood. Then also the semilunar valves would not be stretched towards the Ventricles, and so the Blood squeezed out of the Auricles into the Ventricles, even in the Diastole of the Heart, would be protruded into the Arteries.

Hence it appears that the Blood last driven out of the Heart when the Systole is performed remains unmoved in the Arteries, and therefore that it has received all the Motion of the Ventricles, and therefore that it has communicated the whole partly to the antecedent Blood, and partly to the Coats of the Arteries. *Q. E. D.*

Theorem. IV.

The Motion, which is communicated to the preceding Blood in the Systole of the Heart, is to the Motion communicated to the Coats of the Arteries, very nearly as the time of the Systole of the Heart is to the Diastole.

Dem. Since the Blood is carried with an equal course thro' all the Vessels of the Body, except those parts of the Arteries which are nearest the Heart, it is necessary, that both the Motion lost by the friction of the Blood against

againſt the ſides of the Veſſels, and alſo the Motion given to the Blood by the Syſtole either of the Heart or Arteries, ſhould be equal in equal times. But that Motion, which is communicated by the Syſtole of the Arteries to the Blood, is the ſame preciſely with that which was impreſſed on the Coats of the Arteries by the Syſtole of the Heart, ſince the Arteries are reſtored by the ſame impetus by which they were forced. And the Syſtole of the Arteries agrees in duration with the Diaſtole of the Heart. Whence the propoſition is evident. *Q. E. D.*

Cor. If we ſuppoſe, with the learned Dr *Keill*, that the Syſtole of the Heart is performed in a third part of the time taken between two Pulſes; the Motion communicated to the preceding Blood will be a third part of the whole power of the Heart: but the Motion communicated to the Arteries double the former, or two third parts of the whole power of the Heart.

Theorem V.

In different Animals the power of the Heart obtains a Ratio *compounded of a quadruplicate* Ratio *of any Homologous Diameter of the Animal, and an inverted* Ratio *of the time, in which the Heart is contracted: or a* Ratio *compounded of the* Ratio *of the weight either of the Heart itſelf or of the whole Animal, of a ſubtriplicate* Ratio *of the ſame weight, and of a reciprocal* Ratio *of the time.*

This

This is easily demonstrated either from *Cor.* III. *Theor.* I *and* II. or from the Power of the Heart determined in the preceding Problem.

Cor. I. If we suppose the Power of the Heart to have a Ratio of the weight either of the Heart itself, or of the whole Animal, or of the quantity of Blood in the whole Animal; the length of the Animal will be in a Ratio of the time, in which the Systole of the Heart is performed, or in an inverted Ratio of the frequency of the Pulses.

II. *If the* Ratio of the length of the whole Animal is greater than the inverted Ratio of the frequency of the Pulses, the Ratio of the Power of the Heart must necessarily be greater than the Ratio of it's weight.

Schol. As it appears from Experiments that the Pulses of Boys are not so much more frequent than the Pulses of Men, as Boys are exceeded in length by Men, it must be concluded, by the second Corollary, that the Power of a Man's Heart has a greater Ratio to the Power of a Boy's Heart, than is the Ratio of the weights. And it is the same in the other Muscles. For if the strength of the Body was to follow the Ratio of the weight, Boys would be able to perform journies of equal length in the same time with Men.

In the same manner as we have determined the Motion of the Blood bursting out of the Ventricles of the Heart by the second *Theorem*, may the Motion also of the Urine flowing out of the *Urethra* be determined. For if we suppose the length of the *Urethra* and Bladder equal to 12 inches, and that two ounces of Urine

Urine are emitted in a ſecond of time, the Motion of the effluent Urine will be equal to the Motion of a weight of 1 $\frac{1}{2}$ ℔ which may run the length of an inch in every ſecond. But becauſe the Urine is expelled not only by the contractile Forces of the Bladder, but alſo by the aſſiſtance of the Diaphragm and Abdominal Muſcles, the Power of the Bladder cannot be eſtimated by the Motion of the profluent Urine.

I beg, Sir, that you would give a favourable reception to theſe papers; and I heartily wiſh, for the public Safety, that you may long enjoy your health, and continue to increaſe the eſteem the World has of you, and to promote the dignity of the Æſculapian Art.

Jan. 1, 171$\frac{7}{8}$

An Anſwer to the foregoing Diſſertation, by JAMES KEILL *M. D. in a Letter to the Learned Dr* MEAD.

SIR,

Philoſ. Tranſ. num. 361. *pag.* 995.

I HAVE read Dr *Jurin's* Letter addreſſed to you, and lately publiſhed in the Philoſophical Tranſactions; in which that learned Gentleman endeavours to weaken what I have ſaid of the Force of the Heart. As the calculation of the Force, with which the Heart expels the Blood, made by *Borelli*, ſeemed almoſt incredible to every one, I thought it no raſh attempt, not injurious to the reputation of *Borelli*, no offence to the learned World, to endeavour to come nearer to the Truth. In which Eſſay I did not propoſe to give an accurate determination of the Force of the Heart, but rather to point out a method, by which this Force might perhaps be found out; and to incite thoſe who are better ſkilled in Geometry to inveſtigate a Problem which was greatly wanted. I ſhall endeavour now to defend this Eſſay againſt the learned Gentleman's objections, with the ſame diſpoſition of mind, with which I firſt ſet about it. For I am not in queſt of any Honour (my Reputation, how ſmall ſoever it is, is certainly greater than I deſerve) but rejoyce at any light that is given to Phyſick from any quarter. Therefore I ſend you this Letter not to ſupport my own Determinations, but that one, who is more than equal to this taſk, may be pleaſed to look over his Demonſtrations again,

I and

and give them more correct to the Republic of Learning. For as my Adversary has besought you to be his Patron, so I desire to leave this Controversy to your Determination, who are a fit and learned Judge of it.

The chief Error which he objects to me and Dr *Moreland* is, that in calculating the Power of the Heart, we have endeavoured to determine what Ratio it has to a dead weight, or to the weight of the Body. 'But as the 'Heart itself is moved, says he, when it con-'tracts, and as it impels the opposite bodies, 'the Blood and Coats of the Arteries, into 'Motion, it is plain that there is no other 'way of discovering how great it's *Power* is, 'than by finding out the quantity of this 'Motion. But it is as impossible to compare 'any *Motion* with a quiescent weight as a line 'with a Rectangle.' But I do not know that either of us has compared the *Motion* of the Heart with a quiescent weight. But I do not see what should hinder us from comparing the Power of the Heart, or the Force that moves the Heart and impels the Blood, with a weight. For tho' there is no relation between the *Weight* and the *Motion* of a solid body, yet the moving Force, if it acts on a Fluid, has certainly some proportion to the Force of Gravity. And indeed the moving Force of a body, causing a certain quantity of Motion in a given time, is equal to the weight, which acquires the same quantity of Motion, in falling by the force of Gravity, in the same time. Hence the Force, by which Water is pressed out of any Orifice, is said to be equal to a certain weight: because a given weight, and

and the Force which presses the Water out, generate equal Motions in equal times. This seems to me to be the genuine Sense of Sir *Isaac Newton*'s Corollary, nor does what I have said of the Force of the Heart differ from this Sense. Sir *Isaac Newton*'s words are, *the Force, by which the whole Motion of flowing Water can be generated, is equal to a weight, &c.* to which Dr *Jurin* does not seem sufficiently to have attended, when he says, *the weight by which the Motion of Water flowing out of a Vessel may be generated &c.*

But if I have erred in this, I have erred with the principal Geometricians of this age, *Huygens* and Sir *Isaac Newton*, who both explain the Force of Fluids by the Force of Gravity. Nor does Sir *Isaac Newton* do this only in the beforementioned *Corollary*, but he shews also in other places a method, by which the Ratio of the resistance of a *Medium*, that is, of the action of a fluid on a solid body, to the Force of Gravity or the Centripetal Force may be found, as may be seen in *Prop.* IV *and* V of *Lib.* II, and their Corollaries. Surely the action of Fluids upon a Solid, and of Solids one on another is different. A Fluid moved with a given Velocity can sustain a given weight, when the parts of the Fluid continually succeeding each other impinge on the weight, and so the Force of the Fluid is really equal to a weight; but as the Ratio of solids is different, their Force cannot be compared with Gravity.

This ingenious Gentleman reproves me again, for making the Velocity of the Blood driven out of the Heart equal thro' the whole Systole,

which he has ſhewn to be very unequal. But I never made the Velocity of the Blood equal, but put the middle Velocity for the ſum of all. But whether the ſwiftneſs of the Blood thrown out of the Heart is equal or unequal, is not yet plain to me; but the Argument for the equal Velocity appears to me at preſent the ſtrongeſt.

Having vindicated the Errors which the learned Gentleman imputes to my firſt Method: let us ſee now what offends him in the other. And it is certainly that Poſition which is uſed often by *Borelli* and other learned Men, that the Forces of ſimilar Muſcles are in Proportion to their Weights. Dr *Jurin* endeavours to eſtabliſh another Ratio of the Forces in his Vth *Theorem:* but as the Demonſtration ariſes from the common Principle of all his Theorems, it will be involved alſo in the ſame fate with them: for if that Principle is fallacious, as it ſeems to me, and does not agree with the caſes to which it is applied; all muſt certainly fall to the Ground which is built on this Foundation. The learned Gentleman ſuppoſes that the Coats of the Veſſels Forcibly ſtrike the Blood contained in them, and communicate part of their Motion to the Blood by the ſtroke: and here in the Motion of the Heart, he will have it that the Ventricle as a ſolid Body, moved with a given Velocity, impinges on the Blood, and beſtows on it part of it's own Motion by the ſtroke: which Suppoſition neither agrees with the Motion of the Blood, nor of the Heart, nor of the Air preſſed out of the Lungs, nor can it be ſo accommodated to theſe Motions, by any reiteration of the

 ſmalleſt

ſmalleſt ſtrokes, as not to ſhew the Concluſions drawn from it to be uncertain and altogether falſe.

As there is no ſpace between the Blood and the inſide of the Heart, but one is contiguous to the other, the Heart does not act upon the Blood by ſtriking, but by Preſſure: nor have the Ventricles any ſwiftneſs at the beginning of their Contraction, but acquire ſwiftneſs in time by contracting themſelves, as heavy Bodies by falling, or Fluids by rarefying, from which perhaps all the Force of the Heart ariſes. And therefore the Motion of Contraction is not equable, as the learned Gentleman would have it, but is a Motion accelerated like that of falling. There is the ſame difference, therefore between the ſtroke with which Dr *Jurin* would make the Heart ſtrike the Blood, and the Preſſure with which the Heart really acts upon the Blood, as between the action of a ſolid Body in Motion, and the Force of Gravity: but by his own Confeſſion, theſe cannot be compared, and therefore the Preſſure or Action of the Heart upon the Blood is neither explained by a ſtroke by the learned Gentleman, nor ever can be ſo explained. This Opinion is confirmed by the Power of the Heart found by himſelf. For if a weight moved with a given Velocity were equal to the Power of the Heart, then the Blood impelled directly againſt that weight with all the Force of the Heart, would deſtroy the Motion of the weight in a moment of time: but with how great a Force ſoever the Blood is driven againſt the weight, it will never take away all it's Motion in an Inſtant, and therefore the Power

Power of the Heart is leſs than this weight, and the Force of the Heart is not rightly explained by the Motion of a weight.

Dr *Jurin* always calculates the Forces of Fluids upon ſolid Bodies, in the ſame manner as the Forces of ſolid Bodies upon each other, when there is the greateſt difference between them; and from hence flows all the error of his Propoſitions. For when a ſolid Body, whoſe Parts firmly cohere, impinges on another, every Particle of the Body at once, and but once, beſtows it's Force on the other, but it is otherwiſe in Fluids, in which there is no coherence of Parts, no part of a Fluid, unleſs when it touches, acts on the oppoſite Body; therefore when a column of Water is turned upwards againſt a ſolid Body, the more diſtant parts of the column from the Body impreſs no Force upon it. A ſolid Body alſo communicates but one ſtroke to another; but a column of Fluid acts continually on the oppoſite Body, and the leaſt part of the column in the leaſt moment of time impreſſes an infinitely ſmall ſtroke on it, altogether in the ſame manner that heavy Bodies act by falling, to which therefore the Motion of Fluids is rightly compared. Moreover all the Motion of a ſolid Body directly impinging on another, may be deſtroyed in a moment of time: but the Motion of a ſolid impreſſing a Force on a Fluid, is only gradually diminiſhed, and vaniſhes in a given time, in like manner as Gravity exerts it's Force on a Body thrown upwards. From which it abundantly appears, that there is a great affinity between the Force of a Fluid put in Motion, and the Force of

Gravity, and that one may be rightly explained by the other; but that the Force of a ſolid Body cannot be referred to the Force of Gravity. And ſince the learned Dr *Jurin* ſeems not to have ſufficiently attended to this difference, he ſeems to have greatly erred from the Truth. If therefore he will be pleaſed to lay aſide his Hypotheſis of the ſtriking of the Veſſels, and take the Force of Preſſure, which nature uſes, for his principle, and conſtruct other Theorems of the Motion and Force of the Heart and Blood, after his elegant method of Demonſtration, he will greatly oblige me, and do ſervice to the learned World. And for your part, Great Sir, who hold the firſt rank in Phyſick, be pleaſed ſo to moderate by your prudence the diſputations of thoſe who differ in opinion, that they may not be contemptible to the unlearned, but profitable to the learned.

Northampton,
June 23, 1719.

A Defence

A Defence of the foregoing Dissertation, by James Jurin, *M. D. F. R. S. in a Letter to the Celebrated* Richard Mead, *M. D. Fellow of the College of Physicians, and of the Royal Society.*

Sir,

I HAVE diligently read over the Apology of the most excellent Dr *James Keill*, who was lately taken off by an untimely death, to the great loss of all the learned. In reading which I could not forbear greatly admiring the singular Humanity and most candid disposition with which he treated me, while I differed from his sentiments, and also the greatness of his mind, and love to the learned World, worthy of so great a man. For he did not only diligently strive to oblige them thro the whole course of his life, but when he was overcome by a severe disease and found himself to be dying, he left behind him that learned Epistle as the last pledge of his love. To which however I am obliged to return an answer, not that I distrust your piercing judgment, but that the authority of so learned a Man may not prejudice other less capable readers. Be pleased therefore, Learned Sir, to receive my objections to his Defence, and be the judge whether being drawn by love of contention I treat his *Manes* with too much severity, or whether I dispute like one who is more sollicitous for the Truth than for Victory.

Philos. Transact. num. 362. *pag.* 1039.

In the firſt place the celebrated author complains that I have unjuſtly cenſured him, with the learned *Borelli* and *Morland*, as comparing the Motion of the Heart with a dead weight. Indeed, when I had firſt noted that a certain Motion of the Blood and Arteries aroſe from the Force of the Heart, I ſaid that the quantity of the Power of the Heart could not be known, unleſs we knew the quantity of this Motion: and that no Motion could be compared with a quieſcent weight, any more than a line with a Rectangle. By which words I meant, not that theſe learned Gentlemen had expreſsly compared the Motion of the Heart with a quieſcent weight; but that they, when they explained the Power of the Heart by a weight, had ſhewn no method, by which the quantity of the Motion ariſing from the Power of the Heart could be calculated. The celebrated Dr *Keill*, if I rightly underſtand his meaning, endeavours thus to take off this objection. The Power of the Heart conſiſts in preſſure, and beſtows it equably on the Blood, in the ſame manner altogether, as the Force of Gravity drives a weight downwards, and accelerates it into Motion by perpetual action. Therefore, ſince the Power of the Heart is equal to a weight determined by Sir *Iſaac Newton*'s Corollary, it will impreſs the ſame Motion on the Blood during the Syſtole, as that weight will acquire in the ſame time by falling by the Force of Gravity. As the learned Gentleman explains his meaning, I confeſs that this my objection will be entirely taken off; namely if the Power of the Heart is equal to the beforementioned weight, and conſiſts

consists in an equable pressure continued thro' the whole Systole. But of those two propositions the learned Gentleman can in no wise endeavour to prove the latter, but sets it down as a Hypothesis: tho' I had endeavoured by producing some reasons to shew the contrary opinion to be more probable; that the Power of the Heart does not act equably on the Blood thro' the whole Systole, but when it has collected all it's Force in a small particle of time, rushes at once upon the Blood, and drives it out of the Ventricles, in the same manner as I have explained at large in my Epistolary Dissertation. But I shall shew by and by, that the first proposition is false, even granting the learned Gentleman that Hypothesis.

As for the sense of Sir *Isaac Newton*'s Corollary, I will not give the reader much trouble about it, seeing I think it neither concerns him, which of us best understood Sir *Isaac*'s meaning; nor that my learned Adversary has so perspicuously explained his opinion, as to cause any danger of my fixing any such sense upon it, as he would reject, if he were still able to defend himself. But it will be worth while to take notice, that when Dr *Keill* speaks of the Force with which Water is pressed out of any Orifice, Sir *Isaac Newton* has not one single word in that Corollary, by which Water is signified to be pressed out by any Force; but has only determined the weight equal to that Force, by which the whole Motion of effluent Water may be generated, or which may acquire a Motion by falling by the Force of

Gravity equal to the Motion of Water flowing out in the ſame ſpace of time.

But that the celebrated author did not rightly underſtand that Corollary, or at leaſt that he did not make a right uſe of it, will eaſily be perceived by the learned Reader, who does but obſerve what difference there is between the efflux of Water out of a hole in the bottom of a Veſſel always full, as it is conſidered by Sir *Iſaac Newton* in that Corollary, and the efflux of Blood out of the Heart into the Aorta. For in the former caſe the Water has already acquired it's whole Velocity, and flows equably out of the hole in a given ſpace of time. But the Force of the Heart, by Dr *Keill*'s Hypotheſis, is applied to the Blood at reſt in the Ventricle, and propels it towards the Aorta in the firſt moment of time with an infinitely ſmall Velocity ; but the equable preſſure being continued, at length it impreſſes a finite Velocity on it, and continually increaſes it, till it has driven all the Blood out of the Ventricle.

Again, in Sir *Iſaac Newton*'s caſe the Motion is conſidered, not of the whole Water contained in the Cataract, which is all put in Motion, and tends towards it's exit with a different Velocity, but only of the Water in the very hole and now coming out. But the Force of the Heart impreſſes the Motion on the whole maſs of Blood contained in the Ventricle, and propels it all towards the Aorta.

Laſtly, I deny that the weight of five ounces determined by the learned Gentleman, can acquire that quantity of Motion during the

the Syſtole of the Heart by the Force of Gravity, which the Power of the Heart produces, even granting him that Hypotheſis, that the Power of the Heart conſiſts in an equal preſſure. For by this Hypotheſis, the Motion produced by the Power of the left Ventricle will be according to my Calculation [page 69, and 71.] equal to the Motion of a weight of about eighteen pound, which may run the length of an inch in every ſecond. But the Motion, which a weight of five ounces during the Syſtole of the Heart, if all the reſiſtance of the Arteries and preceding Blood be taken away, or will acquire in the tenth part of a ſecond by the Force of Gravity, will be equal almoſt to the Motion of a weight of twelve pound, to be moved with the above-mentioned Velocity. But if any one has a mind upon aſſuming this Hypotheſis, to determine the true weight which is equal to the Power of the Heart, he will find it by the calculation made to be a weight of about ſeven pounds and a half. For this will acquire during the Syſtole of the Heart almoſt the ſame Motion by falling, as the Power of the Heart produces.

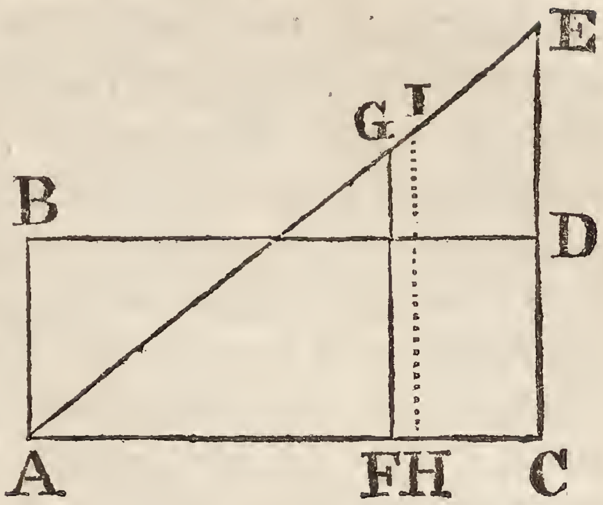
But ſome one perhaps will ſay, that the difference juſt now made between the Motion acquired by Dr *Keill*'s weight, and the Motion ariſing from the Power of the Heart may proceed from thoſe poſitions not being very accurate by which I have reduced the Algebraical Characters uſed in my Calculation to numbers. To ſatisfy which doubt, and at the ſame time to ſhew that I ſhould have found a far greater difference, if thoſe poſitions had not

not happened to favour Dr *Keill*; it will be worth while to aſſume ſome more ſimple caſe, in which a given bulk of Water is preſſed thro' a given Orifice, in a given time, by ſome Force or equable preſſure, which are the conditions laid down by my Antagoniſt to determine the Power of the Heart.

But in that caſe I ſhall demonſtrate that neither the Motion of effluent Water, nor the Motion at length impreſſed by that Force on the whole bulk of Water is equalled to the Motion of Water in Sir *Iſaac Newton*'s Corollary; nor that Force or Preſſure to the weight determined by that Corollary. Which if I make good, Dr *Keill*'s whole demonſtration muſt neceſſarily fall to the ground.

I will aſſume therefore a given Cylinder of Water, contained in a Cylindrical Tube of an infinite length; and that Section of the Tube to which either Surface of the Water reaches ſhall be for the Orifice, and to the other Superficies a Force ſhall be applied by means of an *Embolus* of the ſame Diameter with the Tube. Now let any given quantity of Water flow out in a given time thro' the ſaid Section of the Tube; and another equal quantity thro' a Hole of the ſame Diameter made in the bottom of a Veſſel, which is kept full according to Sir *Iſaac Newton*'s manner: and in the firſt place let us ſee whether the Motion of the effluent Water will be alike in both caſes.

Let



Let the time of the efflux of the Water be expressed by the right Line A C, and the equable Velocity, with which the Water flows out of the Hole in the bottom of the Vessel by the right Line A B. Whence the bulk of Water flowing out of the Hole, as it is in a joint Ratio of the time and of the Velocity, will be expressed by the Rectangle A B C D; and the Motion of it will be expressed by a solid Parallelipiped, drawn from the same Rectangle into the height A B, as it is in a Ratio compounded of the Ratio's of the Bulk and of the Velocity.

In the other case, where the Water flows thro' the Cylindrical Tube, the time, as before, will be expressed by the same right Line A C; but the Velocity of the Water will be in a Ratio of the time, as the Force applied, according to the Hypothesis, acts equably on a given Bulk of Water, and therefore will be represented by the mutable right Line F G, proportional to the right Line A F, or to the time of efflux from the beginning. But the *Molecula* of Water flowing thro' the said Section in the particle of time F H, will be expressed by the Rectangle drawn from itself F H into F G which expresses the Velocity; or if the *Rectula* F H be understood to vanish, by the *Trapezium* F G I H, and the Bulk of Water flowing thro' in the whole time A C

 will

will be ſignified by the Rectangular Triangle A C E. And becauſe by the Hypotheſis that Bulk is equal to the Bulk of Water flowing out in the former caſe, the Triangle A C E will be equal to the Rectangle A B D C; whence C E, or the Velocity acquired at the end of the time A C, will be double the Velocity C D or A B, with which the Water flowed out of the Hole in the bottom of the Veſſel. But the Motion of the Water paſſing thro' in the particle of time F H, as it is in a joint Ratio of the Bulk and Velocity, will be expreſſed by the evaneſcent Priſm, which is made of the *Trapezium* F G I H drawn into the Velocity F G: whence the whole Motion of the Water flowing thro' in the whole time A C will be expreſſed by a Pyramid, whoſe Baſe is the Square of the right Line C E, and whoſe perpendicular Altitude is A C. Which Pyramid being to the Parallelipiped defined in the former caſe as 4 to 3, the Motions alſo of the effluent Water will be in the ſame Ratio in both caſes, and therefore unequal, which I undertook to demonſtrate in the firſt place.

In the next place I am to ſhew, that the Motion at length impreſſed on all the Water contained in the Tube is not equal to the Motion determined in the firſt example. But here as all that Bulk of Water is not defined by the abovementioned poſitions, I will ſuppoſe it equal to the Bulk expreſſed by the Rectangle A B C D, which in the firſt caſe flows out of the Hole, and which in the ſecond flows thro' the mentioned Section. Whence as the whole Motion at length impreſſed on it is in a Ratio of the Bulk, and of the Velocity acquired at

the end, it will be expressed by the Parallelepiped of the Rectangle A B D C drawn into the right Line C E. But this is to the Parallelepiped, determined in the first case, of the same Rectangle and the right Line C D, as the Altitude C E to the Altitude C D, or in a double Ratio. Moreover, if we might express the Bulk of Water contained in the Tube by any other Rectangle, instead of the Rectangle A B C D, it thence appears that this Motion may obtain any Ratio to the Motion determined in the first case, and therefore that it is not equal to it. Which was to be demonstrated in the second place.

In the last place I am to shew that the Force applied in this case is not equal to the weight determined by Sir *Isaac Newton*'s Corollary. Now this Force and the Force of Gravity acting on that weight, as they are both equable, will be according to the Motions produced from them in a given time. And as it was just now demonstrated that they are unequal, those Forces also will be unequal. Which was to be demonstrated in the last place.

The learned Gentleman proceeds to another fault which I had found in his Solution, his having made the Velocity of the Blood flowing out of the Heart equable, which is demonstrated by me to be very unequal. But he denies that he had ascribed an equable Velocity to the Blood, and says he only made use of a middle Velocity for the sum of all the different Velocities. Besides, he says it does not yet appear manifest to him, whether the Velocity of the Blood thrown out is equal or unequal,

unequal, but he thinks the argument for the equal Velocity to be the ſtrongeſt. But whether one who endeavouring to find the Velocity of the Blood applies the Bulk of the expelled Blood to the Orifice of the Aorta, without any mention either of the different Velocities or of the middle Velocity, makes the Velocity of the Blood equable, let the learned Reader judge: who will alſo eaſily find, whether any Force or preſſure applied to a Fluid at reſt in a Veſſel, which is the learned Gentleman's Hypotheſis, will drive out that Fluid in the firſt moment of time, with the ſame Velocity as at the end.

The learned Gentleman thinking that he has thus anſwered the Objections which I had brought againſt his firſt Method, now proceeds to vindicate the other more eaſy one. In this I had obſerved that he aſſumes that Propoſition, that the Force of the Heart in different Animals is according to the weight, and ſuppoſes the Velocity of the Blood flowing out of the Iliack Artery being cut, equal to that with which the Blood is emitted out of the Heart into the Aorta, both which poſitions I have demonſtrated to be falſe. The learned Gentleman does not defend the laſt error, but ſupports it by the authory of *Borelli* and other learned Men who have often made uſe of that ſuppoſition. And indeed I have reprehended ſuch a ſuppoſition in *Borelli*, nor is any man's authority to be oppoſed againſt a real demonſtration. In the laſt place therefore he is pleaſed to take my demonſtration to pieces. This he thinks depends upon ſome fallacious Principle, on which, as all my

Theorems

Theorems are built, he involves them all in the ſame ruin. For he ſays that I ſuppoſe that the Ventricles of the Heart, like a ſolid Body moved with a given Velocity, impinge upon the Blood, and by that ſtroke communicate part of their Motion to it. Which Hypotheſis he thinks agrees neither with the Motion of the Blood, nor of the Heart, nor of the Air preſſed out of the Lungs.

As for the Lungs, ſince the learned Gentleman has been pleaſed juſt to touch upon them, I acknowledge that I have conſidered the Lungs when they contract as impinging on the contained Air with a given Velocity, and I profeſs that I did it deſignedly. For as *Bellini*, and many other very learned Men, amongſt whom my celebrated Antagoniſt is not the leaſt, have delivered much about that Force, by which the Air acts upon the Blood paſſing thro' the Lungs in Exſpiration, and diſſolves it's *Moleculæ*; which ſolution they think happens at the very beginning of the exſpiration; I propoſed to weigh this their opinion. But I ſaw, that if I ſuppoſed the Air to be expelled by an equable Force or preſſure, the Motion impreſſed by the Lungs on the Air at the beginning of the Exſpiration, or the re-action of the Air on the Lungs, and ſo on the Blood flowing thro, muſt be eſteemed an infinitely ſmall quantity, and therefore could perform none of thoſe effects which were aſcribed to it. If I had done thus, I thought the followers of *Bellini* would juſtly complain, that I dealt unfairly with them, in rejecting their opinion for the ſake of a demonſtration drawn from an arbitrary Hypotheſis,

pothesis, and the most adverse that could be. Therefore I chose to deduce my demonstration from that Hypothesis which most favoured them, and ascribed the greatest quantity of Motion to the Air at the beginning of the Exspiration. And it was that, by which the Lungs are supposed at the beginning of Exspiration to impinge on the Air with a given Velocity.

But in determining the Power of the Heart, I propose in the first place that Hypothesis, by which it's Ventricles, having acquired the whole *impetus* in a moment of time, rush upon the Blood, like a solid Body endued with a given Velocity, as the most simple of all, and thence deduce the Solution. But afterwards I consider both that Hypothesis, by which the Ventricles of the Heart receive all their Motion in a very small particle of time, and which seems to me the most probable, and also Dr *Keill*'s Hypothesis, and others without number, and accommodate my Solution to them all. So that, whether that principle be found uncertain and fallacious, or true and firm, no degree of certainty will thereby be taken away from my Solution.

But I do not see any argument brought, why I may not use that supposition, as well as the learned Gentleman the contrary one of Force or Pressure. I do not disown that there is no space between the sides of the Ventricles, and the Blood, and still it is not yet clear why the thing cannot be performed by a stroke. Certainly if a stroke be impressed on a Cube touching a Globe, the Cube will communicate to the Globe part of the Motion

impressed

impreffed on itfelf, as eafily as if there was a fpace between them.

But thefe are folid Bodies, and the Motion of Fluids is quite another thing. The learned Gentleman indeed explains at large the difference between the ftrokes of folid Bodies, and the action of a Solid on a Fluid; or of a Fluid on a Solid; of which difference as he thinks I was not aware, he pronounces that all the error of my Propofition flows from that head. But I willingly admit that difference as rightly ftated by him, and fay that I was by no means ignorant of that common Doctrine, fince nothing occurs more frequently in Mechanical writers, but that I fhewed fome new cafes, to which as that Doctrine could not be applied, a different method was to be taken from that hitherto ufed. This may be explained in three words. For, to ufe a very eafy example, let a Cylinder of Water of a given length be fuppofed to be at reft in a given Tube, and let another folid Cylinder of like Diameter be moved thro' that Tube, and impinge with a given Velocity on the Watry Cylinder. What will be the event? Why the whole Cylinder of Water will be put in Motion by that ftroke, in the fame manner as if it had been a folid Cylinder: but the other Cylinder will lofe part of it's Motion in a moment of time, and both Cylinders will be carried thro' the Tube with a common Velocity. It will be the fame, if the Watry Cylinder flowing thro' the Tube impinges on the folid Cylinder being at reft. But if the Watry Cylinder be carried thro' the Tube with a given Velocity, and the folid Cylinder meet

it with another Velocity, ſo that the quantities of the Motions of the watry and of the ſolid Cylinder be on both ſides equal, the Motion of both Cylinders will be deſtroyed in a moment of time, in like manner as if two ſolid Bodies endued with equal Motion were to meet each other. The learned Reader will eaſily make out any more compound caſes from my diſſertation *De Motu Aquarum fluentium*, and will ſee alſo how that can be done, which my learned Antagoniſt ſeems moſt to have wreſted, namely that I have taught that the Blood ruſhing out of the Ventricle with it's whole *impetus* may be ſtopped, if a ſolid Body runs againſt it endued with a given quantity of Motion.

But whereas the moſt candid Gentleman friendly adviſes me to lay aſide my Hypotheſis of the ſtroke of the Veſſels, and applying the Force of Preſſure, which he thinks Nature uſes, for a principle, to conſtruct other Theorems; he might have obſerved that I have done that already, if the ſeverity of his diſeaſe had not occaſioned to him look but perfunctorily over my Diſſertation. For when I ſuppoſe the Motion of the Heart to be increaſed according to the time, I make uſe of the ſame Hypotheſis, as if I had applied the Force of Preſſure. And this being laid down, I have determined the Motion ariſing from the Power of the Heart to be twice as great as if the thing was performed by the ſtroke of the Ventricles. But the Calculation itſelf I left to be made by the Reader, as being eaſy enough, and like my firſt. But the following Theorems and amongſt them the fifth, which the learned

learned Gentleman is for rejecting, as being deduced from the Hypothesis of the stroke of the Ventricles, do not at all depend on that Hypothesis, but are with the same ease demonstrated from the Hypothesis of my learned Antagonist.

I do not doubt but that if he had been now alive, his great sagacity would easily have perceived the truth of this; but as we have lost that great Light of Physick, I propose it to be weighed and judged by other learned Men. But chiefly to you, Learned Sir, whose authority was of great weight with him, as it is of the greatest with me, I most willingly submit this whole controversy, as to a most fit, and impartial Judge.

ESSAYS
ON
SEVERAL PARTS
OF THE
Animal Oeconomy.

ESSAY IV.

Of Animal Secretion.

IN explaining the Manner, how the ſeveral Fluids of the Animal Body are ſeparated from the Blood, I ſhall ſhew,

Firſt, *How they are formed in the Blood, before they come to the place appointed for Secretion.* And,

Secondly, *I ſhall demonſtrate in what manner they are ſeparated from the Blood by the Glands.*

The Blood conſiſts of attracting Particles. The Blood of all Animals, when drawn out of the Body, does naturally, and of it ſelf, divide into two different parts: Of which the Red does in a little time coagulate, but the Serum

Serum remains fluid. If we view a drop of Blood with a Microſcope, we diſcern a number of Red Globules ſwimming in a limpid Fluid; and perceive how the Globules, attracting one another, unite like Spheres of Quickſilver, which, as they touch, run into one another: And conſequently the Blood divides into two parts.

The Serum conſiſts of attracting Particles.

After the Coagulation of the Red Globules of the Blood, if we examine the Serum with a Microſcope, we find in it likewiſe a great number of Corpuſcles of various Figures and Magnitudes, ſwimming in a limpid Fluid. Theſe do not attract and unite with one another as the former did, till ſome part of the Fluid, in which they ſwim, has been evaporated by Heat; and then they likewiſe attract one another, and form a Coagulum, as the Globules did.

This therefore is matter of fact, that the Blood conſiſts of a ſimple and limpid Fluid, in which ſwim Corpuſcles of various Figures and Magnitudes, and endued with different Degrees of an attractive force. Now of ſuch Particles, as the Blood conſiſts of, muſt the Fluids be compoſed, which are drawn from it; and as in the Blood the Particles attract one another, and cohere together, ſo likewiſe may the Particles of the Fluids which are ſeparated from it.

Moſt Fluids conſiſt of attracting Particles.

Moſt of the Liquors we know are formed by the Coheſion of Particles of different Figures, Magnitudes, Gravities, and attractive Powers, ſwimming in an aqueous Fluid, which ſeems to be the common Baſis of all. Why are there ſo many ſorts of Water, differing

from one another in Properties? Is it not, becauſe of the Corpuſcles of Salts and Minerals with which the Element is impregnated? What elſe is Wine but Water impregnated with the Particles of the Grape, and Ale with Particles of Barley? Are not all Spirits the ſame Fluid ſaturated with ſaline or ſulphureous Particles? And all Liquors are more or leſs Fluid, according to the greater or ſmaller Coheſion of the Particles, which ſwim in this aqueous Fluid; and there is hardly any Fluid without this Coheſion of Particles, as is apparent by the Bubbles which ſtand upon the Surface of Water, Wine, and even of ſome Spirits.

The Secretions conſiſt of attracting Particles. But that ſome of the Fluids, which are ſecerned by the Glands from the Blood, are actually compoſed by the Coheſion of ſeveral ſorts of Particles, is very evident. We know that in Milk there are three or four ſeveral ſorts of Subſtances, and yet when it is examined by the Microſcope it appears, like Blood, to conſiſt of very ſmall Gobules, ſwimming in a limpid Fluid. Urine has the ſame Appearance, and contains perhaps more Principles: And there is no doubt but that Tears, Spittle, and Sweat are all compounded Liquors. If ſome of the Fluids which are ſecreted by the Glands are not eaſily reſolved into their compounding Parts; we can no more conclude from thence, that they are not compounded, than we can that the Blood is not, becauſe it does not ſeparate into about thirty different Fluids, which are conſtantly extracted from it by the Glands.

The Reaſon why it If the Particles, which attract one another, are ſtill more powerfully attracted by the Particles

Particles of the Fluid in which they ſwim, than by one another, they can never of themſelves ſeparate from the Fluid; and this is the caſe of all Salts diſſolv'd in a large Quantity of Water, and of Urine, when it neither breaks nor ſettles. But if the Particles, which ſwim in the Fluid, are more ſtrongly attracted by one another, than they are by the Fluid in which they ſwim, then this Fluid muſt neceſſarily go into parts; and the Corpuſcles uniting, will either ſink, ſwim, or aſcend in the Fluid, according to their ſpecifick Gravities; unleſs there ſhould be ſo many Interſtices within the coagulated Maſs, as will receive the greateſt part of the Fluid. From hence it is plain that the red part of the Blood conſiſts of Particles which attract one another, more than they do the watry Fluid, in which they ſwim; and that the other Particles which are in the watry Fluid of the Serum, are more attracted by it, than by one another. But if part of this watry Fluid be evaporated, by which means the Particles attracting approach nearer, the Force of their Attraction is increaſed, and they unite; and conſequently this force muſt be much ſtronger in Particles that are very nigh one another, than when they are at a diſtance. *is not evident in all.*

This Power by which the Particles of the Blood attract one another, is the ſame with that which is the Cauſe of the Coheſion of the Parts of Matter, and was firſt communicated to me by my Brother at *Oxford*, above ſeven Years ago; who had no ſooner diſcovered it, but he deduced from it the Coheſion of the parts of Matter, the Cauſe of the Elaſticity of *This Attraction is an univerſal Power in Matter.*

 Bodies,

Bodies, of Fermentations, Diſſolutions, Coagulations, and many other of the Operations in Chymiſtry. And ſince it will appear, that the whole Animal Œconomy does likewiſe depend upon this attractive Power; it ſeems to be the only Principle from which there can be a ſatisfactory Solution given of the *Phænomena* produc'd by the *Minima Naturæ*; as that other attractive Principle, which is of a different kind from this, and was firſt diſcovered by the incomparable Sir *Iſaac Newton*, demonſtratively explains the Motions of the great Bodies of the Univerſe; which is not in the leaſt diſturb'd by the attracting Power we now ſpeak of, which only exerts it ſelf in Particles that are a ſmall diſtance from one another. Now, that there is ſuch an attractive Power in Nature as this we have mentioned, I think, can be denied by none, that duly conſider the Experiments and Reaſons given for it by Sir *Iſaac Newton*, in the Queſtions annexed to the Latin Edition of his Opticks.

From this Principle that the Blood conſiſts of Corpuſcles of various Figures and Magnitudes, and endued with various Degrees of an attractive Power, and that of ſuch Particles the Fluids ſecerned by the Glands are compoſed; I ſay, from this Principle (for which we have ocular Demonſtration) I ſhall endeavour to ſhew how the Corpuſcles that compoſe the Secretions are formed in the Blood, before they arrive at their ſecerning Glands, having firſt laid down the following Propoſitions, being only ſo many of the Laws of Attraction as at preſent we have occaſion for; the reſt being

being contained in my Brother's Theorems publiſhed in the *Philoſophical Tranſactions.*

Prop. I. *There is a Power in Nature by which each Particle of Matter attracts every other Particle, with a Force that increaſeth in a greater Proportion than that, by which the Squares of the diſtance decreaſe,* viz. *in a reciprocal triplicate, or quadruplicate Proportion to the diſtances.*

Some Laws of Attraction in ſmall Particles of Matter.

For were the Particles that compoſe the attracting Body endued with a Power that attracted only with a Force reciprocal to the Squares of the Diſtances, the Attraction would not be much ſtronger at the Contact than at ſome determined Diſtances from it: As is evident in the Caſe of Gravity, which ariſes from a Power of attracting reciprocally as the Squares of the Diſtances; Bodies being of the ſame Weight, when they touch the Earth, as they are at an hundred Feet diſtance. But by all Experiments, this Power is much greater at the Contact, or extremely near it, than at any determined Diſtance. The Particles of Salt diſſolved in a large quantity of Water, do not ſenſibly attract one another, till part of the Water has been evaporated; by which means approaching each other, their attractive Force increaſes, they run to one another, and uniting form Cryſtals, whoſe Parts have a ſtrong Coheſion. And therefore the Force, by which each Particle attracts every other Particle, muſt increaſe in a much greater Proportion, than that by which the Squares of the Diſtances decreaſe.

Prop. II. *The attractive Force is* cæteris paribus *proportional to the Solidity of the Particles.*

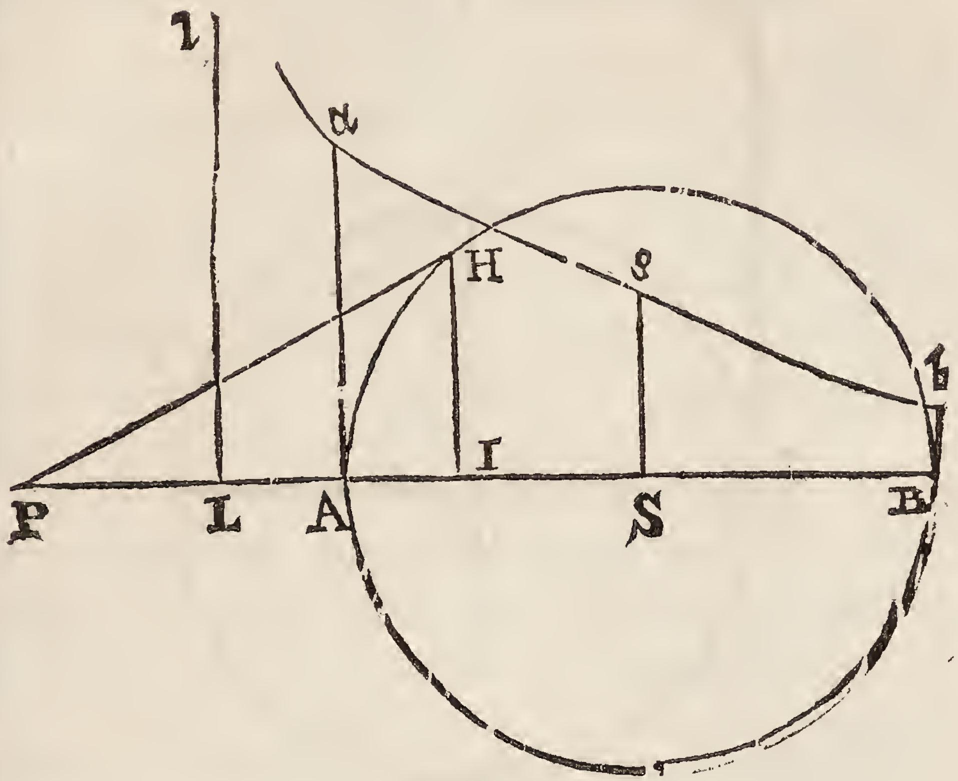
The

The attractive force of a Particle is composed of the Sum of all the Attractions of the Parts of that Particle: Now these Parts are most numerous in the most solid Particles, and therefore *cæteris paribus*, their attractive Force is strongest.

Schol. This Proposition is to be understood of the smallest Particles of Matter, and not of the Corpuscles made up of those Particles. For Corpuscles may be so compounded, that the most solid and compact Particles may make up the lightest Corpuscles, if the Interstices between the Particles be large, so that few of them may be diffused thro' a great Space: Such a Corpuscle, tho' it consists of Particles that are endued with a strong attractive Power, may yet be specifically lighter than another, which consists of Particles not so solid, but closer together. And such sort of Corpuscles I conceive all Salts to be, whose Particles of the last Composition are very solid, but that there are great Interstices between those Particles, into which the Water rushing with a force, being strongly attracted, dissolves the Texture of the Corpuscles.

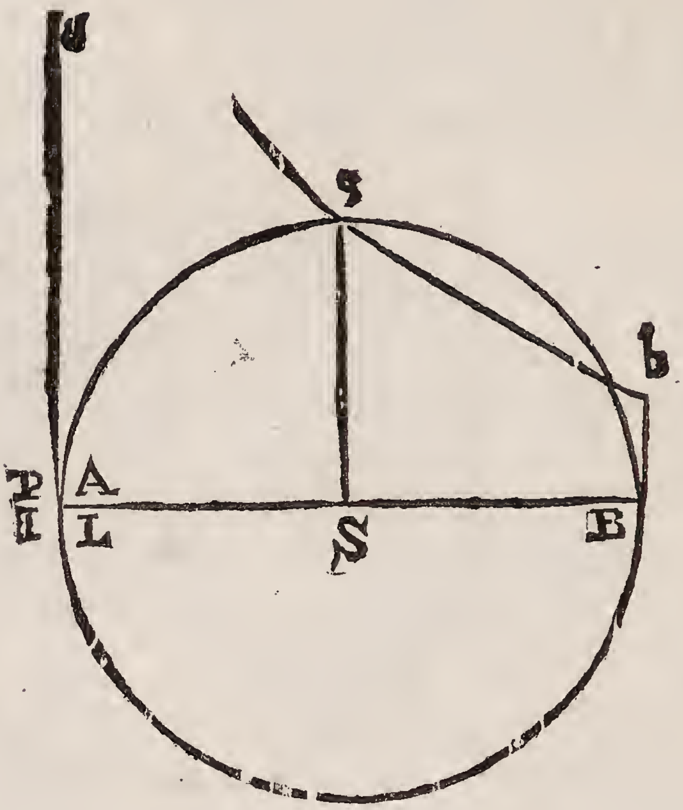
Prop. III. *If Particles of Matter attract each other with a Force, that is in a reciprocal triplicate, or a greater Proportion of their Distances, the Force by which a Corpuscle is drawn to a Body made up of such attractive Particles, is infinitely greater at the Contact, or extremely near it, than at any determined Distance from it.*

Suppose



Suppose the Sphere A H B composed of Particles, that attract a Corpuscle P with a Force reciprocally proportional to the Cubes of their Distances. Draw the Tangent P H, and from H let fall the perpendicular H I, bisect P I in L, and raise the Perpendiculars L l, A a, S s, B b, and make S s = to S I: with the Asymptots L B, L l thro' b s, describe the Hyperbola b s a, and the Area a A B b — the rectangle 2 A S × S I will represent the Attraction of the Corpuscle P, by the 81 Prop. of Sir *Isaac Newton*'s Principles.

But when the Corpuscle P comes to the Sphere, and touches in A, then the Points P, L, A, I, and H, coincide, and A a becomes the



the Asymptot of the Hyperbola, and the Area a A B b a becomes infinite, and the rectangle 2 A S × S I being finite, the Area a A B b a — 2 A S × S I, will be infinite; and consequently the Force, by which the Corpuscle P is attracted by the Sphere, will be likewise infinite.

If the Sphere consists of Particles that attract in a reciprocal quadruplicate Proportion of their distances, the Force by which a Corpuscle will be drawn to the Sphere will be as $\frac{1}{PS^2 \times PI}$. Now when the Corpuscle comes to touch the Sphere, P I becomes = 0, and consequently whatever is divided by it, becomes infinite, and therefore the attractive Force

Force of the Sphere, at the Contact being proportional to $\frac{1}{PS^2 \times PI}$ will be infinite.

Prop. IV. *If a Body consists of Particles attracting with a Force that is in a reciprocal Proportion to the Cubes of the distances, or in a greater; and if this Force is not infinitely greater than the Force of Gravity at the Point of Contact, or extremely near it, at any determined distance from the Point of Contact, it must be infinitely less than the Force of Gravity.*

This is clear by the last Proposition: Or in that Case the Force of Attraction in a Corpuscle removed from the Contact is infinitely less than at the Contact, or extremely near it; but at the Contact it is not infinitely greater than the Force of Gravity by Supposition: Therefore the Force, by which a Particle removed at a determined distance from the attracting Body is attracted, is infinitely less than the Force of Gravity.

Prop. V. *The Force, by which the Particles of Matter attract each other, when extremely near the Contact, is not infinitely greater than the Force of Gravity.*

This is evident: Because in the strongest cohesion of Particles touching one another, we find that the Weight of some Bodies will pull the Particles asunder, tho' that Body may be prodigiously greater and heavier than the Particles united. Sir *Isaac Newton* calculates from the Inflection of the Rays of Light, that this Force near the Contact is 10000 0000 0000 0000 greater than the Force of Gravity.

Corol. Particles removed at a determined distance from the Body attracting, are not acted

upon

upon by it; becauſe this Force muſt then vaniſh, or, which is the ſame thing, be infinitely leſs than the Force of Gravity.

Prop. VI. *A large Particle attracts not more ſtrongly than a ſmall one of the ſame Solidity, but a Diverſity of Figures cauſes different Degrees of Attraction in Particles that are otherwiſe the ſame.*

This attractive Power acts only on ſuch Particles as are extremely near; and therefore of a large Particle, the remoteſt parts conduce nothing to Attraction: And for the ſame Reaſon the attractive Force varies, according as the Particles are Cones, Cylinders, Cubes, or Spheres, and *cæteris paribus* a Spherical Particle, has the ſtrongeſt attractive Power.

Prop. VII. *If Particles ſwimming in a Fluid, attract one another more ſtrongly, than they do the Particles of the Fluid, the Force by which they come to each other, will be that by which their attractive Force exceeds the attracting Force of the Fluid.*

For the Particles of the Fluid, that lie directly between the attracting Particles, being more preſſed than the other ambient Particles; they will from the Nature of Fluidity, with that exceſs of Preſſure, drive the other Particles out of their places, and make way for the attracting Particles to come together.

Prop. VIII. *If Particles ſwimming in a Fluid, are more attracted by the Fluid, than by one another, they will recede from one another, with a Force that will be equal to the difference of their mutual Attraction, and the Attraction of the Fluid.*

For

For the ambient Particles of the Fluid attracting more ſtrongly, will with their exceſs of Force draw the other Particles to themſelves, and make them to recede from one another.

Prop. IX. *The Force, by which Particles attracting one another cohere, is greater* cæteris paribus, *where the Contact is greater.*

For the parts that are farther remov'd from the Contact, conduce nothing to the Force of the Coheſion; and a greater Power muſt be requiſite to ſeparate two Particles, which cohere in two points, than two Particles which cohere only in one point, if the Degree of Coheſion be equal in each point. Thus two poliſhed Marble-ſtones (ſuppoſe a Foot ſquare) adhere more ſtrongly than any other two Bodies of a Foot ſquare, which are not ſo ſolid but have more Pores and Interſtices between their parts, and which will not receive ſo good a poliſh, by which the parts come to a cloſe Contact with one another.

Prop. X. *If the attracting Corpuſcles are elaſtick, they muſt neceſſarily produce an inteſtine Motion, greater or leſſer, according to the Degrees of their Elaſticity and attractive Forces.*

For after meeting they will fly from one another with the ſame Degree of Velocity, (abating the reſiſtance of the Medium) that they met together with; but when they approach other Particles in their Reſilition, their Velocity muſt increaſe, becauſe they are afreſh attracted, and therefore meeting a ſecond time, they will recede with a greater Velocity than they did at their firſt Concurſion; and ſo their Velocities will be increaſed by every Con-

cursion and Resilition, which must necessarily produce a sensible intestine Motion; and the stronger their attractive Force, and the greater their Elasticity, their Concursions and Resilitions will be the more sensible.

Prop. XI. *Particles attracting one another in a Fluid, moving either with a swift or slow progressive Motion, attract one another just the same, as if the Fluid was at rest, if all the Particles move equally; but an unequal Velocity of the Particles does mightily disturb their Attractions.*

The Particles do all by Hypothesis move equally and constantly, the progressive Motion of the Fluid does not alter their Distances, that is to say, it does not repel them from one another; and consequently they must attract one another with the same Facility, as if the Fluid was at rest. But if some Particles move faster than others, some must change their Position in respect to each other, and those parts, which by the Force of Attraction would have come together, will by this unequal Motion be carried from one another. Thus Salts do not crystallize, nor the terrestrial Particles of Urine attract one another, and unite, till the Water in which they are dissolved, is almost cold; and the intestine Motion of its Particles, caused by Heat, is quieted.

These are the Laws by which Secretions are first formed in the Blood, before they are separated by the Glands. The Particles of the Blood returning by the Veins mutually attract one another, and cohering form Globules too big for any Secretion; and therefore there was an absolute necessity that they should be broken and divided in the Lungs by the Force of Respiration:

Reſpiration: Which becauſe it is commonly thought to be inconſiderable, by reaſon we are not ſenſible of it, I ſhall therefore here make an Eſtimate of it.

The Force of the Air upon the Blood in breathing determined.

It is a known Experiment, that by blowing into a Bladder we can raiſe by the Force of our Breath a conſiderable Weight: Having therefore got an oblong Lamb's Bladder; which being tied at both ends was nearly of a Cylindrical Figure, I fixt a Pipe into one end, and tied a Weight to the other; I then faſtned the Pipe at ſuch a diſtance from the Ground, as juſt allowed the Weight to reſt upon the Ground. The Bladder being thus fixt, I found that by the force of an eaſy Expiration, I could raiſe 7 ℔ Weight, and the greateſt Weight I could raiſe by the ſtrongeſt Expiration was 28 ℔. Now the Force by which the Air entered the Pipe was that Force by which it was drove out of the Lungs: If therefore we can determine the Force by which the Air entred the Pipe, we have the Force by which it was drove through the *Aſpera Arteria.*

But the preſſure of the Air upon the Bladder is equal to twice the Weight it can raiſe, becauſe the upper part of the Bladder, being fixt, reſiſts the Force of the Air, juſt as much as the Weight at the other end: And again, ſince the Air preſſes every way equally, the whole preſſure will be to that part of it which preſſes on the Orifice of the Pipe, as the whole Surface of the Bladder is to the Orifice of the Pipe; that is, as the Surface of a Cylinder, whoſe Diameter was 4 Inches and Axis 7, is to the Orifice of the Pipe. The Diameter

of the Pipe was 0.28, and therefore its Orifice was 0.0616; the Surface of the Cylinder was 88: Therefore as 88 : 0.0616 : : 14, double the leaſt Weight raiſed, to 0.098, which is almoſt two Ounces, and in raiſing of the greateſt Weight it is near 7 Ounces. Theſe therefore are the Forces by which the Air is drove thro' the *Aſpera Arteria* in an eaſy and a ſtrong Expiration. Now if we conſider the Lungs as a Bladder, and the *Larynx* as a Pipe, the Preſſure upon the Orifice of the *Aſpera Arteria* when the Air is drove out, is to the Preſſure upon the Lungs, as the whole Surface of the Lungs is to the Orifice of the *Aſpera Arteria.* Let us ſuppoſe the Diameter of the *Larynx* to be 0.5, (which is more than it can be) then the Orifice of the *Larynx* is 0.19. Let us ſuppoſe the two Lobes of the Lungs to be two Bladders or Spheres, whoſe Diameters are each 6 Inches, their Surfaces are 113 Inches each, and the Preſſure upon the *Larynx* will be to the Preſſure upon the whole external Surface as 0.19 to 226, which is as 1 to 1189; and therefore if the Preſſure upon the *Larynx* in an ordinary breathing is 2 Ounces, the Preſſure upon the whole external Surface of the Lungs is 148 ℔; and the utmoſt Force, when the Preſſure upon the *Larynx* is 7 Ounces, will be equal to 520 ℔ weight: But the Lungs are not like an empty Bladder, where the Air preſſes only upon the Surface; for they are full of Veſicles, upon the Surface of each of which the Air preſſes as it would upon the Surface of an empty Bladder; and therefore to know the whole Preſſure of the Air, we muſt determine the internal Surfaces

of the Lungs. To do this, let us ſuppoſe that $\frac{1}{3}$ part of the Lungs is taken up with the Branches of the *Trachæa Arteria*, that another third Part the Blood Veſſels fill, and the Remainder is Veſicles, where we ſuppoſe the chief Preſſure upon the Blood Veſſels to be made. Now both Lobes of the Lungs contain 226 ſolid Inches, of which $\frac{1}{3}$ or 75 Inches are full of Veſicles. Let the Diameter of each Veſicle be $\frac{1}{50}$ part of an Inch, the Surface of a Veſicle will be .001256, and the Solidity 0000043, by which Sum if we divide 75, the Space filled by the Veſicles, the Quotient gives us 17441860, for the Number of Veſicles in both Lobes of the Lungs. This Number multiplyed by .001256 the Surface of a Veſicle, gives the Sum of the Surfaces of all the Veſicles, to wit, 21906.976 Inches. And therefore the Preſſure upon the *Larynx*, will be to the Preſſure upon the whole Surface of the Lungs, as 0.19 to 21906.976; and conſequently when in an ordinary Expiration the Preſſure upon the *Larynx* is 2 Ounces, the Preſſure upon the whole internal Surface of the Lungs will be 14412 ℔ weight, and the utmoſt Force of the Air in breathing, when the Preſſure upon the *Larynx* is 7 Ounces, will be 50443 ℔ weight. Tho' theſe ſeem to be prodigious Weights, yet it muſt ſtill be underſtood, that the Preſſure upon each Part of the Surface of the Lungs equal to the Orifice of the *Larynx*, is not greater than it is at the *Larynx*, and that theſe vaſt Weights ariſe from the vaſt extent of the Surfaces of the Veſicles, upon which it was neceſſary that the Blood ſhould be ſpread in the ſmalleſt capillary

Veſſels; that each Globule of Blood might as it were immediately receive the whole Force and Energy of the Air, and by that be broke into ſmaller Parts fit for Secretion and Circulation. And from thence we may learn the mechanical Reaſon of the Structure of the Lungs: For being the whole Blood of the Body was to paſs thro' them, in order to receive the Virtue of the Air, and that could not be communicated but in ſmall capillary Veſſels, it was neceſſary that the Surfaces upon which they were to be ſpread, ſhould be proportioned to their Number, which is admirably well provided for by the wonderful Fabrick of the Lungs.

The Effects of the different Gravities of the Air conſidered upon Aſthmatick People.

If the Gravity of the Air was always the ſame, and if the Diameter of the *Trachæa Arteria*, and the time of every Expiration were equal in all, this Weight upon the Lungs would be always the ſame. But ſince we find by the Barometer, that there is 3 Inches difference between the greateſt and the leaſt Gravity of the Air, which is a $\frac{1}{10}$ part of its greateſt Gravity; there muſt be likewiſe the difference of a tenth part of its Preſſure upon the Lungs at one time and another: for the Momenta of all Bodies, moved with the ſame Velocity, are as their Gravities. This is a difference, which ſuch as are Aſthmatick muſt be very ſenſible of, eſpecially if we conſider that they likewiſe breath thicker, that is, every Expiration is performed in leſs time; if in half the time, and the ſame Quantity of Air drawn in, then the Weight of the Air upon the Lungs muſt be 57648 ℔ of which $\frac{1}{10}$ part is 5764 ℔, and conſequently aſthmatick People upon

upon the greateſt Riſe or Fall of the Barometer, feel a difference of the Air, equal to above $\frac{1}{3}$ of its Preſſure in ordinary breathing. Again, if the *Trachæa Arteria* is ſmall, and its Aperture narrow, the Preſſure of the Air increaſes in the ſame Proportion, as if the times of Expiration were ſhorter; and therefore a ſhrill Voice is always reckoned amongſt the prognoſtick Signs of a Conſumption, becauſe that proceeds from the narrowneſs of the *Larynx*, or *Trachæa Arteria*; and conſequently increaſes the Preſſure of the Air upon the Lungs, which upon every Expiration beats the Veſſels ſo thin, that at laſt they break, and a ſpitting of Blood brings on a Conſumption apace.

By this Preſſure of the Air, the Coheſions of the Globules of the Blood are diſſolved.

I ſuppoſe, no body doubts whether this Preſſure of the Air upon the Lungs in breathing be ſufficient to break the Globules of the Blood, and to diſſolve all the Coheſions they might contract in their Circulation thro' the Arteries and Veins. And when the Blood is thus diſſolved and thrown out by the Heart into the Aorta; it is evident that the re-union of the Particles requires more or leſs time, according to their ſeveral attractive Powers, even tho' they all moved with the ſame Velocity, and in the ſame Direction.

How the Union of the Particles is hindred near the Heart.

But neither doth this happen, for a Fluid moves thro' a Cylindrical or Conical Veſſel (ſuch as the Arteries are) with a greater Velocity at the Axis than at the Sides. And again, the Blood is thruſt into the Aorta by the whole Force of the Heart, and Fluids when they are preſſed preſs *undequaque*, by which means the Arteries are dilated, and the

Blood moves not only forwards, but likewiſe preſſes perpendicularly on the Sides of the Arteries; and as the Sides of the Arteries (being Elaſtick) return, they preſs the Blood from them every way, which muſt produce an inteſtine Motion, and by the 11th Propoſition hinder the Attraction of the Particles, and by this frequent and ſtrong Colliſion of the Particles of the Blood againſt the Sides of the great Arteries, the Coheſions of the Particles, if any of them happen to unite, will be immediately diſſolved. Again, this inteſtine Motion muſt greatly increaſe upon the account that many of the Particles of the Blood are elaſtick: For by this Reſiſtance of the Sides of the Veſſels, they muſt neceſſarily hit one againſt another, and being elaſtick, reflect from one another, and ſo increaſe the inteſtine Motion of the Blood by the 10th Propoſition. Upon this inteſtine Motion of the Blood depends its Heat, which therefore is every where proportional to the *Impetus* of the Particles againſt the Sides of the Veſſels, ſuppoſing the Elaſticity of the Particles every where the ſame. Now the *Impetus* of the Particles againſt the Sides of the Veſſels decreaſes, as the Sum of the Cavities of the Veſſels increaſes; and conſequently where the Sum of the Cavities of the Veſſels is greateſt, there the inteſtine Motion of the Blood is leaſt, and the attractive Power of the Particles, *cæteris paribus*, is greateſt.

The Effects of Steel. By the by, we may obſerve how that Steel, being an elaſtick Body, heats the Blood more than any other Mineral; and how by its Elaſticity, the Force of its own Particles in removing

moving Obſtructions, as well as thoſe of the Blood, increaſe; and therefore it is a better Deobſtruent, than ſome other Minerals, which have a greater Gravity.

What Particles unite firſt.

The Particles which unite firſt after the Blood is thrown out of the Heart into the great Artery, muſt be ſuch as have the ſtrongeſt attractive Force; and ſuch as have the leaſt, unite laſt; and all the intermediate ones according to their ſeveral Natures. The Particles endued with the ſtrongeſt attractive Powers, are by the 2d and 6th Propoſitions, the moſt ſolid ſpherical Corpuſcles, and the Quantity of their Contact being the leaſt, by the ninth Propoſition, the Secretion which they compoſe muſt be the moſt fluid, and ſuch is the Liquor in the *Pericardium*.

The Reaſon of the Situation of the Kidneys.

The Salts are Corpuſcles that are ſtrongly attracted, and have a moſt cloſe Union with the Fluid of Water; for tho' the Lungs may divide the Particles of Salt from one another, yet ſtill they firmly adhere to the aqueous Humour in which they ſwim, and therefore they may likewiſe at firſt be drawn off: Upon which Account the Kidneys have their Situation ſo near to the Heart. And indeed they could not have been placed at a greater Diſtance, and have ſeparated ſuch a Quantity of Urine, as they now do, not only upon the Account of the great Quantities of Blood they receive where they are; but likewiſe, becauſe if they had a more diſtant Station, other Particles muſt have united with the Salts and aqueous Particles (as in their preſent Station ſome terreſtrial Particles do) and conſequently the

Urine could not have been diſtilled ſuch as it is now, or at leaſt but in a ſmall Quantity.

What Particles are longeſt in uniting.

The Corpuſcles, which are the ſloweſt in uniting, muſt be ſuch as have the weakeſt attractive Force, which by the 2^d^ and 6^th^ *Pro*poſitions, are ſuch as have the leaſt Solidity, and ſuch as have their Surfaces the moſt extended; and therefore Corpuſcles, which have plain Surfaces, are longer in uniting than ſpherical Corpuſcles, but when united, they cohere more ſtrongly by the 9^th^ Propoſition, and compoſe the moſt viſcid Fluids: And therefore the moſt viſcid Secretions, ſuch as the Mucilage of the Joints, are ſeparated at the greateſt Diſtance from the Heart, where the Sum of the Cavities of the Arteries is greateſt, the *Impetus* of the Blood againſt the Sides of the Veſſels (which is always proportional to the Velocity of the Blood) ſmalleſt, and conſequently where the Particles move almoſt with an equal Velocity, and therefore the Attractions of the weakeſt are not diſturbed, by the 11^th^ Propoſition.

The Gall which is ſecerned by the Liver, and the Seed by the Teſticles, do ſeem to be two conſiderable Objections againſt what has been ſaid. But I will make it appear that they are ſo far from proving any thing againſt this Doctrine of Secretions, that they are the greateſt Arguments that could poſſibly be urged for the truth of it. Nothing does more evidently demonſtrate the Intentions of Nature in her Operations, than the various Methods ſhe is ſometimes forced to take to bring the ſame thing about.

This

This is most eminently remarkable in the Secretion of the Gall; which, being to be mixed with the Chyle as it comes out of the Stomach into the *Duodenum*; could no where be so conveniently secerned from the Blood, as where the Liver is placed. Now had all the Branches of the Celiack Artery carried all the Blood to the Liver, from which the Gall was to be separated, it is evident, considering the Nearness of the Liver to the Heart, and the intestine Motion of the Blood, that so viscid a Secretion, as the Gall is, could never have been formed in the Blood, and consequently could never have been secreted by any Gland in that Place. In this Case Nature is forced to alter her constant Method of sending the Blood to all the Parts of the Body by the Arteries. Here she forms a Vein (which is no Branch of the *Vena Cava*, as all the others are) and by it she sends the Blood from the Branches of the Mesenterick and Celiack Arteries (after it has passed thro' all the Intestines, Stomach, Spleen, Caul, and Pancreas) to the Liver. By this extraordinary Contrivance the Blood is brought a great way about, before it arrives at the Liver; and its Celerity is extremely diminished, that all the Corpuscles, which are to form the Gall, may have sufficient time to attract one another, and unite before they come to their secerning Vessel. And thus we have found out the Use of the Porta, which, notwithstanding it makes so considerable a Figure in the animal Body, yet perhaps no Part was ever less minded, or had its Use less understood by the Writers upon the Animal Œconomy.

This Doctrine illustrated by the Separation of the Gall in the Liver.

But

But that this is moſt certainly the Uſe of the Porta will more evidently appear, if we conſider what Nature ſtill does farther in Proſecution of the ſame Deſign.

The Cavities of all the Arteries increaſe as they divide. The Sum of the Branches, which riſe immediately from the Aorta, is to the Aorta as 102740 is to 100000: but as if this Proportion was too little to effect the Deſign of Nature, before the Blood arrives at the Liver, the Branches which immediately ſpring from the Trunk of the Meſenterick Artery, increaſe in a much greater Proportion. The Figure of this Artery, as it lies in the middle of the Meſentery, is after this manner. And

in that Body, from which I took the following Proportions, I found 21 Branches to ſpring immmediately from its Trunk. In ſuch Parts of

of which the Trunk of the Mesenterick Artery is 15129

The 1st Branch is	2136
2	1936
3	2136
4	2104
5	4489
6	1936
7	2601
8	3136
9	1681
10	3025
11	625
12	1369
13	1024
14	1849
15	1936
16	529
17	729
18	1156
19	1024
20	1156
21	841
The Sum of all	37418

By these Proportions it appears, that the Sum of the first Branches is much more than double to the Trunk of the Mesenterick Artery; and therefore the Velocity of the Blood in them is much less than half what it is in the Trunk; whereas in the Branches which come immediately from the Aorta, the Diminution of the Velocity is hardly sensible. But that I may put this Matter in a clearer Light, I shall

ſhall firſt examine with what Velocity the Blood in the Liver would have moved, if it had been carried there by ſuch Arteries as are every where elſe. Secondly, I ſhall ſhew with what Velocity it would have moved, had it been brought to the Liver by ſuch an Artery as the *Meſenterica Superior.* And Thirdly, I ſhall demonſtrate the Velocity with which it now moves through the Branches of the Porta to the Liver.

And firſt let us ſuppoſe that an Artery equal to the Meſenterick (the Square of whoſe Diameter is .038025 Parts of an Inch) had gone directly from the Aorta to the Liver, and that the Proportion between its Branches had been the ſame it is every where elſe, to wit, 10000 to 12387. The Logarithm of .038025 is — 1.4189307. The Log. of the ſmalleſt Artery has been found to be — 8.6020600, their Difference is — 7.1831293, which Number being divided by .2080639 (as has been ſhewn in the ſecond Eſſay) the Quotient 34 is the Series of Diviſions of this Artery; and conſequently upon Calculation, the Velocity of the Blood in the laſt Diviſions of the Series, will be found to be to the Velocity in the Trunk of the Artery as 1 to 1448.

But the Velocity of the Blood would have been much leſs if it had been carried by an Artery, ſuch as the Meſenterick, directly to the Liver. I have already ſhewn what Proportion the Trunk of this Artery bears to its firſt Branches; I ſhall now ſet down the Proportion of the ſeveral Trunks to their Branches, that we may find out the general Ratio, as we have taught before.

The

The 5th Branch of the Mesenterick Artery was	4489
Its Branches	1764 2809
	4573
The least of these Branches	1764
Divided into four	576 1225 576 1024
	3401
The biggest Branch	2809
Divided into three	961 1764 1521
	4246
One of these, to wit,	1521
Divided into two	1369 961
	2330
The 8th Branch of the Mesenterick Artery was	3136

Its

Its Branches	1521 1225
	2746
The biggeſt Branch	1521
Divided into two	900 900
	1800
The leaſt	1225
Divided likewiſe into two	729 900
	1629
The 10th Branch of the Meſenterick Artery was	3025
Its Branches	1936 1600
	3536
The biggeſt Branch	1936
Divided into two	1089 1296
	2385
Of theſe the biggeſt	1296

Divided

Divided into two	676
	676
	1352
The 14th Branch of the Mesenterick Artery was	1846
Its Branches	900
	900
	900
	2700
The 15th Branch of the Mesenterick Artery was	1936
Its Branches	1089
	1369
	2458
Of these the biggest Branch	1369
Divided into three	784
	676
	676
	2136
Of which Branch	676
Divided into two	400
	529
	929

From

From all which Numbers, we ſhall take the general Ratio of the Trunks to their Branches, to be as the Sum of all the Trunks to the Sum of all the Branches; that is, as 28549 to 36221, or as 10000 to 12687. Now if we calculate upon this Ratio, we ſhall find 36 Series of Diviſions in the Meſenterick Artery; and that in the laſt of theſe the Blood moves 5261 times ſlower than it does in the Trunk of the Meſenterick Artery.

As the Trunk of the Meſenterick Artery bears a leſſer Proportion to its Branches, than the Aorta does to its Branches; ſo the Branches of the Meſenterick Artery are likewiſe leſs in Proportion to their conjugate Veins, than the Aorta is to the *Vena Cava*. The deſcending Trunk of the Aorta below the Emulgents is to the *Vena Cava* at the ſame Place, as 324 is to 441: But a Branch of the Meſenterick Artery is to its correſponding Branch of the Porta, as 9 to 25: And therefore the Blood in the Branches of the Porta moves 14613 times ſlower than it does in the Trunk of the Meſenterick Artery, and that only upon the Account of the Increaſe of the Diameters of the Veſſels. So neceſſary was it to abate the rapid inteſtine Motion of the Blood, which might hinder the Coaleſcence of the Particles for the Formation of the Bile.

Having ſhewn how the Velocity of the Blood decreaſes as it paſſes to the Liver, I ſhall now enquire into the Time it takes in paſſing. If a Blood-veſſel divides into any Number of Branches, of equal Lengths, and the Orifices of the Branches at each Diviſion increaſe in a certain given Ratio; the Time the Blood will

take to run through ſuch a Veſſel may be thus had. Becauſe the Velocity of the Blood is reciprocally as the Sections of the Veſſels, and the Length the Blood runs being given, the Time is reciprocally as the Velocity; the Time the Blood moves through each Length will be directly as the Section of the Veſſel; that is, directly as the Sum of the Sections of all the Branches: And therefore, if the Sections are in a Geometrical Progreſſion, the Times will likewiſe be in a Geometrical Progreſſion. Suppoſing then that the Time increaſes at each Diviſion of the Veſſel in the Proportion of 1 to r, the Times will be in this Geometrical Progreſſion, $1. r. r^2. r^3. r^4. r^5.$ &c. Now if we call the laſt Term of the Progreſſion u, the Sum of the Progreſſion, that is, the Sum of all the Times will be $= \frac{r u - 1}{r - 1}$: and if we take the Proportion of the Branches of the Meſenterick Artery to be to one another as 10000 to 12687, the Number of Diviſions will be 36, and conſequently ſuppoſing an equal Diſtance between each Diviſion, the Blood moving with an uniform Motion, will require ſeven and thirty times the Time to run through the whole Length of the Meſenterick Artery, that it does to move from the Aorta to the firſt Diviſion of the Meſenterick Artery. In this Proportion r is equal to 1.2687, whoſe Log. is 0.1033589, which multiplied by 36 gives the Logarithm of the Number 5259, which is the laſt Term of the Progreſſion, equal to u, and $r u = r^{37} = 6672$, therefore $r u - 1 = 6671$: Now if

from the Log. of 6671 we ſubſtract the Log. of the Number $r - 1$ or of 0.2687, there will remain the Log. of the Number 24826, which is the Sum of all the Times the Blood takes in moving through all the Diviſions of the Meſenterick Artery; and therefore the Time it takes in moving through the Meſenterick Artery, is to the Time it would run along it with ſuch an uniform Motion as it has at the Beginning of the Artery, as 24826 to 37, or as 670 to 1. Now the Blood in the Aorta or Beginning of the Meſenterick Artery, runs at the rate of 78 Feet in a Minute; and therefore if we ſuppoſe the Meſenterick Artery to be 10 Inches long, the Blood would with an uniform Motion run along it in the Space of 0.64 of a ſecond; and conſequently it muſt now take up near 7 Minutes in paſſing through the Meſenterick Artery. But the Velocity in the Porta is to the Velocity in the Meſenterick Artery as 9 to 25; and therefore if the Porta be ſuppoſed likewiſe to be 10 Inches long, the Blood will be 19 Minutes in paſſing thro' it: So that the Time the Blood takes in paſſing from the Aorta to the Liver is at leaſt 26 Minutes; whereas if an Artery had gone directly from the Aorta to the Liver, (according to the uſual Method of Nature) it had paſſed in little more than half a ſecond, that is, in 2437 times leſs Time than it now requires in paſſing. All which does evidently demonſtrate, that the Blood was not in a State to yield Bile, if it had gone directly from the Aorta to the Liver; that a much greater Time, and a much more languid Motion, than ſo direct a Paſſage could have

have allowed, was abſolutely neceſſary to get the bilious Particles in a readineſs to be ſeparated from the reſt of the Blood in the Liver. I have ſuppoſed the Diviſions of the Artery to be all of an equal Length, which indeed they are not, but may, for the eaſier Calculation, without any conſiderable Error, be taken equal one with another.

We have now ſeen how Nature has provided for the Formation of the Bile in the Blood, which paſſes thro' the Meſenterick Artery. We ſhall next conſider what Care is taken of that which is conveighed by the Celiack Artery to the Liver: For it ſeems it was neceſſary to ſend a larger Quantity of Blood to the Liver, than could be diſpoſed of thro' the Inteſtines. Part of the Blood of the Celiack Artery is ſpread upon the Stomach and Caul, and its Velocity diminiſhed, as we have ſeen, in the Inteſtines; but ſtill all the Blood which theſe Parts could receive, was not ſufficient for the Liver, and there was no more room for the diviſion and expatiating of the Veſſels thro' ſuch a large Space as the Meſentery, and a long Tract of Guts. How therefore muſt the Velocity of the reſt of the Blood (to which the inteſtine Motion is always proportional) be abated? Nature has here another extraordinary Contrivance, ſhe empties the Blood entirely out of the Veſſels into a large ſpongy Bowel, or rather Ciſtern provided for that intent and purpoſe. I know not the Dimenſions of the Splenick Artery, but the Circumference of the Celiack being $\frac{1}{2}$ an Inch, or .5, its Square is .25; and therefore the Square of the Splenick, which is a Branch of

The Uſe of the Spleen.

I 2 it,

it, cannont be above .18. Now the Dimensions of the Spleen are 6 Inches in Length, 3 or 4 in Breadth, and 2 in Thickneſs. I ſhall therefore make this eaſy Suppoſition for the more ready Calculation, that it is a Cylinder of 2 Inches Diameter, and therefore the Square of its Circumference being 36, the Blood muſt move 200 times ſlower in the Spleen, than in the beginning of the Splenick Artery: Is not this the long ſought for Uſe of the Spleen? So productive is one ſimple Truth of many others.

From all this Art and Contrivance it is evident Demonſtration, that the Intent of Nature was to diminiſh the Velocity of the Blood, and that ſuch a ſlow Motion was abſolutely neſſary for the ſecerning of the Bile in the Liver. If the Humours which are ſeparated by the Glands are at all times and places the ſame in the Blood, and not formed after the manner demonſtrated, what need was there for diminiſhing ſo conſiderably the Velocity of the Blood? Let the Blood move faſt or ſlow, they would be always the ſame, and always in an equal aptitude to be ſecerned.

The Proportion of the Bile to the reſt of the Blood.

The Particles which compoſe the Bile, bear a very ſmall Proportion to the reſt of the Blood, as is evident from the great Quantity of Blood that is carried to the Liver, and the ſmall Quantity of Bile that is ſeparated by it. In a large Dog, whoſe *Ductus Cholidochus* was near as big as a Man's, I could never gather above two Drachms in an Hour. Now there is thrown into the Aorta every Hour about 4000 Ounces of Blood: And it appear by the Proportions of the Arteries, that the Meſenterick

terick and Celiack are to the reſt, as 1 to 8; and therefore 500 Ounces of Blood are carried every Hour to the Liver. And ſince only two Drachms of Bile are ſeparated from it, the Bile muſt be to the Blood, at leaſt, as one is to two Thouſand. It is by reaſon of this ſmall Proportion of the Bile to the Blood, that it was ſo neceſſary to allow ſo much Time for the Attraction of the Particles which form the Bile. From this Contrivance of the Porta, the Bile receives another advantage, not leſs conſiderable than the Diminution of the Velocity of the Blood: And that is the Blood paſſing thro' ſo many different Parts before it comes to the Liver, parts with the greateſt part of its *Lympha*, by which means the Particles, that compoſe the Bile, approaching nearer to one another, are by their mutual Attraction ſooner united. And the conſideration of theſe two Contrivances does highly confirm the truth of this Theory of Secretion: For the Diminution of the Velocity of the Blood, and the Subtraction of the *Lympha*, can agree in no other end than the uniting of the Particles of the Bile.

What has been ſaid concerning the Bile, does ſo evidently prove this Doctrine of Secretions, that there ſeems to be no room to doubt of it, even tho' we could not clear the like Difficulty, as to the Formation of the Seed. Yet here again we meet with another Manifeſtation of the truth of it, and we find Nature purſuing the ſame Intentions, tho' in a different manner, the Structure of the Parts not allowing either of the former Contrivances.

Of the Secretion of the Seed.

The Blood is carried to the Teſticles by the Spermatick Arteries; which, contrary to the conſtant Method of Nature in framing the other Arteries, are ſmalleſt where they ſpring from the Trunk of the great Artery, and immediately dilate to a conſiderable Bigneſs: Which evidently ſhews, that there could be no other Deſign in it, but to retard the Velocity of the Blood. We cannot ſuppoſe that the only Intention was, that a ſmall Quantity of Blood might go to the Teſticles: Becauſe then there had been no Occaſion for giving the Artery a different Figure from all others; that narrow Orifice would have been ſufficient of its ſelf for that purpoſe, which the Wideneſs of the Artery immediately afterwards does neither hinder nor further. The Orifices of the Spermatick Arteries were ſo ſmall, that I could not meaſure them, when I took the Dimenſions of the other Arteries; and yet they are hardly gone from the Aorta before they dilate as big, if not bigger than one of the Lumbals, which is 434.2: Now if we ſuppoſe their Orifices to be each 17.3, then the Blood will move 25 times ſlower where the Artery dilates than it does at its Orifice. Again, we conſtantly find that all the Parts of the Body are ſupplied with Blood by ſmall Arteries from the neareſt Trunks. If this Method had been obſerv'd in ſending the Blood to the Teſticles, they had received their Arteries from the Iliacks; and they had ran but a little way, before they had come to the end of their Journey. But inſtead of this, two ſmall Arteries are made to ariſe from the Aorta, a little below the Emulgents, and to march above

above a Foot before they come to the Teſticles. Now if we conſider that the Velocity of the Blood in the ſpermatick Artery, is 25 times ſlower than it is at its Orifice, that is, in the Aorta; and that the Velocity of the Blood in the Iliacks, can be but a very little leſs than it is in the Aorta, where the Spermaticks ariſe; the Blood muſt move 25 times ſlower to the Teſticles, than if it had gone after the ordinary manner from the Iliacks: And becauſe the Space it runs thus ſlowly, is at leaſt ſix times longer than if it had gone from the Iliacks; therefore it muſt be 150 times longer in going to the Teſticles, than if it had gone according to the common courſe of Nature. So that the inteſtine Motion of the Blood is not only allayed, but ſufficient time is afterwards allowed the Particles, which are to compoſe the Seed, to attract and coaleſce before they arrive at the Teſticles.

Some Objections anſwered.

Perhaps it may be ſaid, that the Mucus of the Noſe, and the Wax of the Ear are ſeparated, where the Blood is not ſo languid as their Viſcidity ſeems to require: But I anſwer, that they are Fluids which fall into open Paſſages, where the Air having free Admiſſion, carries off part of their aqueous Fluid; and the Remainder becomes thick, as the Serum of the Blood does, when heated. Beſides, we muſt remember, that tho' the Coheſion of the Particles depends upon their Figures; yet the Force by which they attract one another, is likewiſe in Proportion to their Solidities. So that Particles of equal Magnitudes and ſimilar Figures may cohere equally ſtrongly, yet the moſt ſolid will ſooneſt unite. Hence it is,

that of two Fluids equally viſcid, the heavieſt may be ſeparated in Glands nearer to the Heart than the other; and that two Fluids of different Viſcidities may be ſeparated at the ſame vicinity to the Heart, if the quantity of the Contacts of the Particles be ſuch as will make amends for their want of Solidity.

Moſt if not all the Secretions contain a greater or leſſer Proportion of the aqueous Fluid, which makes them more or leſs viſcid; yet that which contains the greateſt Quantity, may conſiſt of Particles endued with a very ſmall and ſlow attractive Force: and conſequently ſuch a Fluid cannot be ſeparated by any Gland ſo near the Heart, as that which has a leſs Proportion of the aqueous Fluid, and which conſiſts of Particles endued with a ſtronger attractive Force; and this laſt Fluid may be much more viſcid than the other, whoſe Particles are more diluted by the watry Fluid. Now how it comes to paſs that a greater or leſſer Proportion of the aqueous Fluid is ſeparated in any Gland, I ſhall ſhew in the ſecond Part of this Diſcourſe.

But that the different Viſcidities of the Secretions do not depend only on the greater or leſſer Proportion of the aqueous Fluid, is evident from the foregoing Propoſitions; unleſs any one can ſuppoſe that the Blood conſiſts only of one ſort of Particles: Which Suppoſition, beſides that it contradicts matter of Fact, can never account for the Secretion of ſo many different Fluids. And that the Diverſity of the Attractions in the Particles is the Reaſon, why various Velocities of the Blood,

Blood, and Diſtances from the Heart, are required for ſecerning of different Liquors, is moſt evident from what has deen ſaid concerning the Bile, and the Seed. If only a greater or leſſer Proportion of the aqueous Fluid had been requiſite for ſeparating of different Sorts of Fluids, that might have been done any where, as ſhall be ſhewn afterwards; and Nature had not been put to ſo many Shifts and Contrivances, as we have already ſeen.

Some Fluids may be ſecern-ed any where.

As ſome Fluids are only to be ſeparated in certain Velocities of the Blood, and at certain Diſtances from the Heart; ſo there may be others that may be ſeparated any where, and in any Velocity of the Blood. Theſe are ſuch as conſiſt of Particles always in an equal Aptitude to be ſecerned; and tho' ſome of them may contain ſeveral ſorts of Particles, yet the Nature of theſe Fluids does not depend upon the Attraction and Coheſion of their Particles. Such a ſort of Secretion is the *Lympha*, which is a watry Fluid ſecerned in all Parts of the Body, for making the Chyle more liquid. If it be ſaid, that ſince the *Lympha* might have been ſeparated any where, and that it ſerves only to dilute the Chyle, that there ought to have been a particular Gland ſomewhere for it in the *Abdomen*, as being the more proper Place: I anſwer, that a large Quantity of *Lympha* was neceſſary for diluting the Chyle, as appears by the numerous Lympheducts, which diſcharge themſelves into the *Receptaculum Chyli*, *Ductus Thoracicus*, and Subclavian Veins. And if ſuch a Quantity had been ſeparated by a Gland or Glands in the *Abdomen*, appro-

Why the Lympha *is ſecerned in ſeveral places.*

appropriated to that Uſe, they muſt have had very large and conſiderable Arteries. The Liver has $\frac{1}{8}$th Part, and the Kidneys near $\frac{1}{8}$th more of the whole Blood, which paſſes thro' the Aorta; and if the Lymphatick Glands had had $\frac{1}{8}$th Part more (which is the leaſt they could have had) theſe three Parts would have had near one half of the Blood, and the other half muſt have ſerved all the reſt of the Body: Which would have been a very unequal Diſtribution of the Blood. Beſides, Nature is always very ſimple and frugal in her Operations; ſhe never is at any unneceſſary Trouble: And I will ſhew in the ſecond Part of this Treatiſe how the *Lympha* may be drawn off, by Glands appointed to ſeparate other Fluids; ſo that for this Operation ſhe makes no Part, is at no Expence of Blood: But ſhe muſt have been at a very great one, if ſo much *Lympha* had been drawn off by appropriated Glands.

Of the Secretion of Animal Spirits.

I take the animal Spirits to be another Fluid of this Kind. They undoubtedly conſiſt of by far the ſmalleſt Particles in the Blood, as appears by the Minuteneſs of their ſecerning Glands; and therefore they not being formed by the Coheſion of other Particles, might have been ſeparated any where. Yet the Animal Œconomy receives a great Advantage by the diſtant Station of the Brain from the Heart; for if it had been placed nearer, and received the Blood, ſtill divided into its ſmalleſt Particles, by the Force of the Air in the Lungs; ſuch Particles might have entred the Glands, as, afterwards cohering to one another, might have obſtructed ſuch extremely narrow Chan-

nels. Now the Brain being placed at ſuch a Diſtance, the Particles, that by their attractive Power form Corpuſcles, will have ſufficient time to coaleſce, and their Magnitude will hinder their entring into the Glands. For if it ſhould happen, that theſe Particles ſhould enter the Glands, and there unite together, they would then obſtruct the Paſſage to the Nerves, and produce Apoplexies, Palſies, Coma's, *&c.*

The Particles of which the animal Spirits conſiſt, being of ſuch extreme Fineneſs, their Quantity can bear but a ſmall Proportion to the other Fluids in the Blood; and conſequently there was a Neceſſity of a prodigious Number of Glands to ſeparate them from the Blood; and this is the Reaſon of the great Bulk of the Brain.

Of the Number of diffe- rent ſorts of Parti- cles in the Blood.

The Operations of Nature are always the moſt eaſie and ſimple. Now how much more eaſie is it to have the ſeveral Secretions formed after the Manner which has been demonſtrated, than to ſuppoſe as many different ſorts of Particles in the Blood, as there are Fluids ſeparated from it? It is not eaſie to determine, how many different ſorts of Particles are in the Blood. Indeed, Phyſick ſeems in nothing ſo defective, as in the Knowledge of the Nature of the Blood. But if the ſame Pains had been beſtowed upon it in a mechanical Way, that have been, in vain, ſpent in ſearch of its Principles by Chymiſts; we had long e'er now had a more perfect Knowledge of its Nature, than ever we can have by Chymiſtry; which can only ſhew how by Art its Parts may be altered, not what Parts it contains.

A few

A few different ſorts of Particles variouſly combined, will produce great Variety of Fluids, ſome may have only one ſort, ſome two, ſome three, or more; and perhaps the aqueous Fluid is the common Baſis of all the Secretions. If we ſuppoſe only five different ſorts of Particles in the Blood, and call them a, b, c, d, e, their ſeveral Combinations, without varying the Proportions, in which they are mixt will be theſe following.

a b: a c: a d: a e:
b c: b d: b e: c d:
c e: d e: a b c: a d c:
a b d: a b e: a c e: a d e:
b d c: b d e: b e c: d e c:
a b c d: a b c e: a c d e: a b d e:
b c d e: a b c d e.

But whether there are more or fewer in the Blood I ſhall not determine.

Of the Operation of Medicines, which alter the Quantity of the Secretions.

No Theory of Secretion has hitherto been able to give any tolerable Account of the Operation of Purgative, Diuretick, or ſuch Medicines as promote any Evacuation. For if the Humours are every where equally mixt with the Blood, that is, if the Blood is in every Part of the Body the ſame, and its Particles are not more apt to form certain Humours, in ſome certain Parts of the Body than in others; or if they are not forced by the Power of any Medicine to form ſuch Humours; then, and in this Caſe, the Quantities of Humour ſeparated in equal times, will be always as the Velocity of the Blood. But the Velocity of the Blood is ſeldom doubled by any Medicine, and never tripled by the moſt acute Fever, as is evident from the Number of

Pulſes

Pulses in a Minute, which I have rarely found above 120 in the highest Hectick, and I am apt to think there never were 180 Pulses in a Minute, which is triple the Number they generally are. The Quantity of Humour, however drawn off by evacuating Medicines, is often 20 times greater than the natural Quantity; and therefore upon supposition that the Humours are every where equally mixt with the Blood, the Operation of evacuating Medicines can never be accounted for.

Tho' this Argument has the Strength of a Demonstration, yet there are some who explain the Operation of Purgative and other evacuating Medicines by a certain stimulating Faculty which they say they have, whereby the sluggish Juices are not only forced out, but the obstructed Channels opened, and the Motion of the Blood is quickned. But tho' we should allow such a Power in these Medicines, it would remain to be explained, why certain Medicines do only stimulate certain Glands? Why does Jalap affect only the Glands of the Intestines, Mercury the salival Glands, and Nitre the Kidneys? There certainly can be no Account given of their particular Affection or Antipathy, call it which you will: However let us grant they have such, we shall not therefore find them qualified to produce the Effects they do. For first it is evident that evacuating Medicines have some other Power besides the squeezing out the stagnating Juices, because when they are all squeezed out, they still evacuate as much, if they are repeated, as they did before; as is plain by continuing a Salivation for many

Days.

Days. Secondly, we cannot ſuppoſe that all Bodies have every where, and at all times, Juices ſtagnating, but theſe Medicines conſtantly produce their Effects more or leſs at all times. Thirdly, If we ſhould ſuppoſe half the Veſſels obſtructed, an evacuating Medicine could but double the Quantity that was evacuated before it was taken. Fourthly, If theſe Medicines only operate theſe ways, then in a healthful Body, where there were no Obſtructions, they would have no Effect at all. Fifthly, If the removing Obſtructions were the Cauſe of the greater Quantity evacuated, then the Evacuation ſhould ſtill continue in a greater Degree than before the Obſtruction was removed; whereas in Fact we conſtantly find it leſs as the Medicine works off. Sixthly, Tho' a Medicine by ſtimulating a Veſſel may quicken the Motion of the Fluid in that Veſſel, yet it can never increaſe the Quantity of Fluid running thro' it in equal Spaces of time, becauſe it quickens the Motion of the Fluid only by contracting the Veſſel; and therefore the faſter the Fluid is made to run through the Veſſel, the leſs Fluid the Orifice of the Veſſel admits; and conſequently after the Veſſel is contracted by the ſtimulating Medicine, the Secretion will be leſs inſtead of being greater. That a *Stimulus* cauſes the Part upon which it acts to contract, is matter of Fact; and that Purgative Medicines do ſtimulate the Bowels, every one's own Experience convinces him: But perhaps it may be ſaid that they likewiſe ſtimulate the Heart, and increaſe its Force; being they not only quicken, but raiſe the Pulſe; ſo that a greater

ter Quantity of Blood is ſent to the Glands of the Guts: This I readily grant, but deny that this is the principal Action of Purgative Medicines; becauſe that by the ſame Force a greater Quantity of Blood is ſent to all the other Glands of the Body, whoſe Fluids are not however ſenſibly increaſed; and the Glands of the Inteſtines, receive a leſs Quantity in Proportion than any others, becauſe they cannot be ſo much dilated by the greater Force of the Blood, as others, which are not ſo much ſtimulated by the Medicine.

There are others who will have evacuating Medicines endued with an attenuating Quality, by which they diſſolve all the Coheſions of the Particles of the Blood, and ſo ſet the ſeveral Humours at Liberty to paſs through their proper Glands. But if theſe Medicines have a Power to diſſolve univerſally all the Coheſions of the Blood, then every evacuating Medicine would equally and indifferently increaſe the Quantity of every Secretion; Mercury would as conſtantly purge as ſalivate, and Nitre promote Perſpiration as well as Urine; but this is repugnant to Experience. If they have a Power to diſſolve certain Coheſions, and not others, what is this but the ſetting certain Particles of the Blood at Liberty to paſs through their proper Glands, which were not ſo before? And is not this a preparing the Humours in the Blood, in order to increaſe the Quantity of Secretion? Muſt not therefore evacuating Medicines have a Power to affect and operate upon ſome Particles and not others, that is to repel ſome Particles, attract retain and alter others? And this is what

what we affirm to be in all Medicines, and what a thoufand chymical Experiments evince.

There has never yet been any Theory of Secretion which would from one Principle explain the different Operations of evacuating Medicines. The Operation of Purgative Medicines has been generally explained by their ftimulating Faculty, of Diureticks by liquifying the Blood, and Sudorificks by heating and rarifying it. Whereas Nature always acts the moft fimply; and from this one fimple Principle of different Medicines attracting different Particles of the Blood, the Operation of all evacuating Medicines is moft eafily accounted for.

The feveral Humours being formed by the different Cohefions of the Particles of the Blood, the Quantity of Humour fecerned by any Gland, muft be in a Proportion compounded of the Proportion, that the Number of the Particles, cohering in fuch a manner as is proper to conftitute the Humour which paffes through the Gland, bears to the Mafs of Blood, and of the Proportion of the Quantity of Blood that arrives at the Gland. And hence it follows, that where there is a determined Quantity of a certain Humour to be feparated, the Number of the Particles that are proper to compofe the fecerned Liquor, muft be reciprocally proportional to the Quantity of Blood that arriveth at the Gland: And therefore if the Quantity of the Secretion is to be increafed, the Number of the Particles is to be increafed; if the Secretion is to be leffened, the Number of the Particles, that are proper for fuch a Secretion, is to be

leffened

leſſened in the ſame Proportion. Medicines therefore which can alter the Coheſions and Combinations of the Particles, can either increaſe or diminiſh the Quantity of any Secretion. Thus for example, ſuppoſe the Humour which paſſeth through the Glands of the Inteſtines to be compoſed of three or four ſeveral ſorts of Particles; that Medicine which will eaſily cohere to theſe Particles, and cohering increaſe their mutual Attractions, ſo as they unite in greater Numbers at, or before they arrive at the Inteſtines, than they would have done if the Medicine had not been given, muſt neceſſarily increaſe the Quantity of Humour, which paſſeth through the Glands of the Inteſtines, if the Quantity of Blood which arrives at the Glands is not diminiſhed in the ſame Proportion, as the Number of the Particles is increaſed. After the ſame manner do Diureticks, Sudorificks, and Medicines which promote all other Secretions, operate.

If Medicines, which increaſe the Quantity of any Secretion, operate by uniting to, and augmenting the attractive Force of the Particles, which compoſe the Humours to be ſecerned; may not the Particles of ſome Humours, ſooner, more eaſily, and ſtrongly unite to the Particles of ſome ſort of Medicines, than to another ſort? And conſequently, may not different Humours require different purgative Medicines to carry them off through the Glands of the Inteſtines? And does not this re-eſtabliſh the Doctrine of elective Purges, confirmed to the Ancients by Experience and Obſervation, but rejected by the Moderns thro' a falſe Philoſophy? *Specifick Purges.*

Why the increasing the Quantity of some Secretions should diminish that of others, it is not easy to explain by any other Theory. For if the Blood is equally mixt in every Part of the Body with all the Humours which are separated from it, that is, if the Mixture of the Blood is every where alike; so that every Humour bears the same Proportion to the rest of the arterial Blood, in one Part of the Body, that it does in another, (as all other Theories suppose) and if every Humour has its own proper Gland thro' which it is separated; then, what is separated by one Gland, is not subtracted from another, and consequently does not diminish the Quantity of Humour which flows to this other, but indeed does rather increase the Quantity of this other Secretion; for the more any one Humour is carried off, the greater Proportion any other remaining in the Blood, bears to the remaining Blood: And therefore the more any one Secretion is increased, the more all the rest should be increased likewise. But if all the Humours are composed by the Combination of a few different sorts of Particles, then the more apt these Particles are to run into any one sort of Combination, the less all other Combinations must be; and consequently the increasing of any one Secretion, must necessarily diminish the Quantity of all others, but most especially of that which has the most of the same sort of Particles.

If the several Humours which are separated from the Blood, are not formed after the manner we have shewn, then the Blood must be composed of near thirty simple Humours, for

ſo many at leaſt are conſtantly ſeparated from it. But to ſuppoſe the Blood compoſed of ſo many ſimple Humours, as are daily ſecerned in the Glands, is not at all agreeable to that Simplicity which Nature affects in all her Operations. The Principles of all natural Bodies, are ſaid by Philoſophers not to exceed the number five; and yet how prodigious is the Variety, which reſults from their different Mixtures, and Modifications. A few Rays of Light, of different Refrangibilities, mixt all together, produce a white Colour; but variouſly combined exhibit all imaginable Variety of Colours. And can we imagine Nature to have made uſe of leſs Art and Contrivance, in the building of a Fabrick, whoſe every Part demonſtrates the Wiſdom of the Builder, and excites our Wonder and Admiration. No, undoubtedly the ſeveral Humours are compoſed by the various Combinations, and Mixtures, of a few different ſorts of Particles: This is agreeable to the Methods of Nature, which never uſes more Means or Inſtruments, when fewer will do: It is evident that in many of the Humours ſhe actually uſes this Method; and this Method ſuppoſed, gives a more eaſy and ſatisfactory Account of the ſeveral *Phænomena* of Secretion, than has ever yet been given by any other Theory. For if the ſeveral Humours are formed by the various Combinations of a few Particles, what can give a more eaſy and natural Account of evacuating Medicines, than to ſuppoſe them to have a Power of drawing certain Particles of the Blood to one another, in order to form a Humour, which being therefore more abun-

dant in the Blood, muſt neceſſarily be ſeparated in a greater Quantity? And this is no hard, nor unnatural Suppoſition, when chymical Experiments evince that there is ſuch a Power in every Particle of matter. If therefore Medicines have ſuch a Power, and the Humours are compoſed as has been ſaid, it is Demonſtration that evacuating Medicines do operate in the manner has been explained, and that all other Accounts which are contrary to this are falſe and groundleſs.

How it comes to paſs that the Blood in every Individual is more apt to fall into ſome certain Combinations, than it is in others, I freely own my Ignorance; but from this Propenſity ariſes all the different Temperaments and Conſtitutions of the human Body. For it is not the more copious Secretion of any of the more noted Humours, which conſtitutes a Temperament; but it is a certain Proportion of all the Humours amongſt themſelves, and perhaps to every Proportion there is an agreeable Fitneſs and Diſpoſition of the ſolid Parts. The common Nature of Animals allows of as many different Temperaments, as there are kinds of living Creatures; and every Individual of each Kind, may as well have its own proper Temperament, as its peculiar Features and Lineaments. Some Temperaments may differ ſo little from one another, that the leaſt change may make them fall into one another. Others again are ſo widely different, that the whole Force of Nature can never drive the one into the other. And ſeeing the Combinations of the Humours are almoſt infinite, ſome muſt be very ſingular, and very different from the gene-

generality of Combinations; and from thence it is that we find very odd, and remarkable Conſtitutions, in which not only Medicines, but even Meats and Drinks have not their uſual, but many times a quite contrary Effect. And upon this depends the different Appearances of the ſame Diſtemper in different Perſons; and for the ſame Reaſon it is, that what proved ſucceſsful to one, will not always in the like Caſe relieve another.

Nature has not confined the Health of human Bodies to one certain and particular Conſtitution, to which the nearer any other is, the more healthful it is; and the farther from it, the leſs: But as in a Clock, it is not at all neceſſary to its going well, that the Movements be diſpoſed after one certain manner, or that they be joined together in one certain Proportion; but there may be ſeveral Diſpoſitions, and Proportions, all equally good: So there are ſeveral Temperaments, or Conſtitutions, which neceſſarily produce good Health. As every Kind of Animals, tho' of very different Temperaments from one another, may enjoy a perfect Health; ſo undoubtedly this Health may be equally diſtributed to ſeveral Temperaments of each Kind. There are many perfectly beautiful Diſpoſitions of the different Features of the Face, there are many more which cannot be ſaid to be diſagreeable, but the Multitude of ugly ones is almoſt infinite. It is the ſame thing with the Humours of the Body; a perfect Health may be the reſult of various Proportions of the Humours amongſt themſelves; the ſeveral Degrees of Health may ariſe from a much

greater Variety in the Proportion of the Humours; and without doubt there may be innumerable Combinations inconſiſtent with any Degree of Health.

The Knowledge of Secretion neceſſary for the underſtanding the Nature of Diſeaſes.

The Animal Body is nothing but a Machine, whoſe Actions and Motions are all performed by Fluids ſecerned from the Blood, and Secretion is the Spring of all the animal Functions. By its means the Heart beats, the Blood circulates, the Limbs are moved, and the Aliments concocted and digeſted, and in a word, the whole Animal Œconomy, and Life depend upon it; the Blood it ſelf ſeeming to have little other uſe, beſides the recruiting and renewing the ſecerned Liquors. I ſay therefore, ſince Life and Health depend upon the Secretions; ſo likewiſe muſt all Diſeaſes, which are ſaid to be univerſally in the Blood, and many of thoſe which affect particular Parts. If the Quantity and Quality of all the Secretions are ſuch as are proper and uſeful for the ſeveral Purpoſes, for which by Nature they are intended, how is it poſſible but that the whole Animal Œconomy, muſt be in right Order, and that Body in a good State of Health? Unleſs we can ſuppoſe an Error in the firſt Contrivance of the Body; a Suppoſition no Man in his Senſes can make. But if the Quantity of any Secretion exceeds its due Bounds, what Diſorders it makes is evident from a Diarrhœa, Diabetes, Epiphora, Sweatings, *&c.* If the Quantity of any Secretion falls ſhort of what it ought to be, the Effects are of no leſs pernicious Conſequence; as appears from a Suppreſſion of Urine in the Kidneys, from the Jaundice and a Stoppage

of

of Perſpiration. And that the Quality of the Secretions altered do likewiſe create great Diſorders, is obvious from the Pains of the Cholick, of a Diarrhœa, and Dyſentery, from the Sharpneſs of Urine, which ſometimes produces Ulcers in the Bladder and Kidneys; and even the Spittle is known to corrode the Mouth. I have choſen to give moſt Inſtances of ſuch Secretions, as are properly Evacuations, becauſe their Effects are apparent to every Body, and cannot poſſibly be ſaid to be only a Notion. But if the Alteration of thoſe is of ſuch ill Conſequence, what Effects muſt an undue Quantity, or the vitiated Quality of theſe, which are retained in the Body, and employed about the neceſſary Functions of Life, produce? The Diſorders they create, are not ſo evidently the Effects of their ill State, tho' by a juſt reaſoning, we may ſometimes deduce them; and therefore a right Notion of Secretion muſt be of the greateſt Uſe and Importance, for the underſtanding of moſt Diſeaſes.

I ſhall only inſtance in a Diabetes, and from this Doctrine of Secretion explain the Nature of that Diſeaſe hitherto unknown. *Of a Diabetes.* The Symptoms which precede a Diabetes, are little wandring Pains, and frequent Twitchings of the Tendons; theſe are followed by a profuſe Evacuation of a clammy, ſweetiſh Urine, as if Honey were diſſolved in it; which is conſtantly attended with a Thirſt, quick Pulſe, Faintneſs, and Loſs of Strength: All which depend upon the Flux of Urine, and increaſe and diminiſh in the ſame Pro-

 portion

portion with it. The evident Cauſe of this Diſtemper is an habitual drinking of ſtrong Liquors, and the more ſpirituous they are, the ſooner and more violently they bring it. But a Diabetes is not always cauſed by an habitual drinking of ſtrong Liquors, for ſometimes it proceeds from ſome internal and latent Cauſe. However, the Nature of the Diſeaſe is always beſt known, by conſidering what Effects the evident Cauſes of it produce in the Body.

By an habitual drinking of ſtrong Liquors, it comes to paſs in proceſs of Time, that the *Serum*, or thin Part of the Blood, contains a large Proportion of a ſpirituous Fluid; or that Part of the *Serum* which ſhould be Water, is for the greateſt part Spirit. Now the Salts of the Urine or Blood, will not diſſolve in a vinous Spirit, that is, the Particles, of which the Salts conſiſt, are more ſtrongly attracted by one another, than they are by ſuch a Fluid, as by Experiments it appears. And therefore the Quantity of Salts in the Blood, will be daily increaſed, and circulating thro' the capillary Veſſels, muſt irritate the fine Fibres, and cauſe little Pains and Twitchings all over the Body. But when the *Serum* is full of theſe Salts, the diſtance between them and the Globules of the Blood will be leſs; and conſequently they will attract the Globules of the Blood more ſtrongly than the Globules attract one another; and the Globules, or red Part of the Blood, will be diſſolved and diffuſed thro' the *Serum* of the Blood. And this again is confirmed by Experiments; for nothing does

does render the red Part of the Blood ſo fluid, and keep it more from coagulating, when drawn in a Cup, than urinous Salts and Spirits. When the red Part of the Blood is thus diſſolved and united to its *Serum*, it will with the *Serum* be carried off thro' the Glands of the Kidneys, and being united to the Salts, will alter their Figures and Properties; as Litharge and Coral do the Salts of Vinegar, giving them a ſweet Taſte.

All quick Evacuations of the Veſſels muſt diminiſh the Quantity of Fluid ſeparated in the Glands; and therefore the greater Quantity of Urine is voided in a ſmall time, the leſs *Saliva* and animal Spirits will be ſecerned by their reſpective Glands: And conſequently Thirſt, Faintneſs, and Loſs of Strength will increaſe, as the Quantity of Urine excreted increaſeth.

This being the State of the Blood, it is evident that the Indications of Cure, are to diſſolve the Coheſions of the Salts with the Blood, and to carry them off by Urine. Theſe can be anſwered by nothing ſooner or better than Waters, which are therefore to be drunk in large Quantities. And of all Waters, thoſe which have a Tincture of Lime are beſt, becauſe Lime does ſtrongly attract urinous Salts.

I could ſhew the Uſefulneſs of this Doctrine, in explaining ſome Symptoms of Fevers, Rheumatiſms, Small-Pox, and ſome other Diſeaſes, which are not thought to depend upon Secretion; and from thence deduce what things are hurtful, and what uſeful in the ſeveral

ſeveral Methods of curing them: But that would carry me beyond my preſent Deſign, and perhaps may more fuller be illuſtrated ſome time hereafter. I will only take notice, that from this Theory, we have a plain and eaſie Account of the Thickneſs of the Blood in Rheumatiſms; for it is known, that this Diſeaſe ariſing generally from a Cold, the frigorifick Particles entering the Pores of the Skin, not only diſpoſe the Blood to run into ſuch Coheſions as are proper to form the Humours ſecerned in the Glands of the Lungs or Noſe; but they alſo give a ſtrong Attraction and Coheſion to the Particles ſwimming in the *Serum* of the Blood, which will be ſtrongeſt in the Extremities where the Motion of all the Particles is near equal by the 11th Propoſition. That it is in this manner our Blood is affected in Colds, and not by the Stoppage of the Pores, as is generally thought, I could very evidently prove. This equal Celerity of the Particles of the Blood in the Extremities, is likewiſe the Reaſon why the Concretions of the Gout are formed there; unleſs by frequent Debauches, or a Decay of Nature, the Motion of the Blood becomes ſo languid, that theſe Particles eaſily attract one another in the Blood-veſſels of the Bowels, where I have ſhewn that the Motion of the Blood is alſo very ſlow: And then ſuch Remedies as warm and increaſe the inteſtine Motion of the Blood, and thereby diſturb the Attraction of the gouty Particles, relieve the Bowels, and ſend the peccant matter to the Extremities again. To this Attraction of the

Of Rheumatiſms.

Of the Gout.

the Particles in the Urine, is owing the Formation of Gravel and Stone in the Kidneys and Bladder; and the Nucleus of the Stone in the Bladder, being almoſt equally ſurrounded every where with the Fluid of Urine, its Attractions are almoſt every where equal; and therefore the Stone is made up of ſo many parallel Shells or *Laminæ*. Now from this it demonſtratively follows, that copious and liberal drinking muſt neceſſarily prevent the Growth of both: For by that the attractive Particles are removed at a diſtance too great to attract one another. Provided always that the Drink be ſuch, as is not highly ſaturated with Particles, which eaſily and ſtrongly attract one another; what theſe Drinks are, they who know the Nature of the Liquors which are commonly drunk will eaſily underſtand. *Of the Stone.*

As this Principle of Attraction will account for moſt Diſeaſes; ſo I doubt not, but that by it likewiſe the Operations of all ſorts of Medicines may be explained. For example, Medicines which thicken the Blood, are ſuch as conſiſt of very ſmall Particles, and endowed with a ſtrong attractive Force, by which eaſily cohering to the Globules of the Blood, they increaſe their Attraction to one another, and ſo produce a Coagulation, or at leaſt a thickening of the Blood. On the contrary, if a Medicine conſiſts of ſuch Corpuſcles, as will eaſily unite with the aqueous Particles, and increaſe their Attraction; ſo that they attract the Globules of the Blood with a greater Force than theſe Globules attract one another, then will *The Operations of Medicines explicable by Attraction.*

will the Globules recede from one another, be diffused thro' the *Serum*, and the *Coagulum* be dissolved. A *Gonorrhœa* is undoubtedly produced by a very active Salt, which being strongly attracted by the Humour in the Glands, and uniting to it, like the Acids of Salt and Vitriol to Mercury in the Preparation of Sublimate, forms a very virulent *Pus*, which corrodes the Vessels, and produces Ulcers. And as Sublimate loses its corrosive Faculty by the Addition of more Mercury, which strongly attracts its acid Salts; so Mercury mixt with the Blood, attracts the acid Salts of the Pox, and uniting to them, carries them off, either by Stool, Spittle, or otherwise. This Power, by which Mercury attracts acid and sharp Salts, is the Reason why Cinnabar is so good a Medicine in fixt and vagrant Pains, as in a Rheumatism: For the Urine of Rheumatick Persons is found upon Examination, not to contain its due Quantity of Salts, which therefore being retained in the Blood turn acid, and produce Pains.

The Operation of Mercury.

Now who can doubt of the Truth of a Principle so simple, and yet which like a Master-key opens Works of very different Contrivances, and discloses an Uniformity in all the Operations of Nature; so that every one may see and read the same Thought and Hand in the Contrivance and framing of every part of the Universe. By it we see the Reason why the Branches of all the Arteries in the Body, have the Sum of all their transverse Sections greater than the transverse Section

Section of the Aorta; for if it had been otherwise, there could have been no Mucilage separated for the easy Motion of the Joints, without such a Structure as the Spleen at every Joint where this Mucilage was necessary. By it the Reason not only of the general Structure of the Vessels is demonstrated, but likewise the Necessity of the Frame and Situation of the particular Parts, as of the Lungs, Spleen, Porta, and of all the Glands. By it the Nature of the Blood and all the Secretions may be explained. By it the whole Animal Œconomy, and all its Disorders, the several Diseases incident to the Body, the Nature of their Remedies, and the ways of their Operations may be accounted for. This is that grand Principle, by which all the Particles of matter in this Planet are actuated. By which, but with a different Force, all the Planets are carried round the Sun; and as the projectile Velocity of the Planets, adjusted to the Sun's Attraction, causes them to move in their several Orbits; so the Velocity of the Blood, adapted to the Attraction of its Particles, causes the several Humours to be secerned at certain distances from the Heart by their respective Glands.

I shall now proceed to the second thing I proposed to shew; which is, *The manner whereby the several Fluids, after they are formed in the Blood, are separated from it by the Glands.*

This does depend entirely upon the Figure and Structure of the Glands; which must be therefore first determined. As Truth

when plain and evident does of itſelf diſpel all falſe Opinions; ſo the true Structure of the Glands being once demonſtrated, there will be no Occaſion to refute the Doctrine of Ferments; nor the Hypotheſis of Tubes differing as to the Figures of their Orifices, both which have been ſeveral times demonſtrated to be falſe.

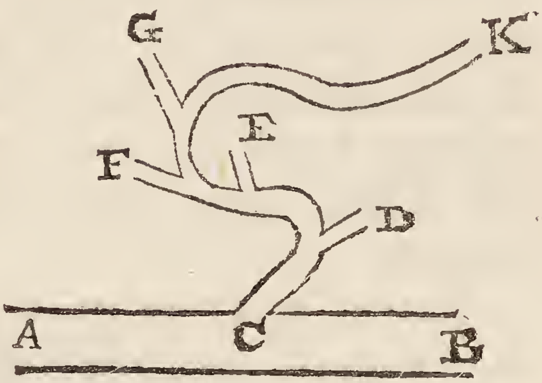
That the Glands are nothing but Convolutions of ſmall Arteries, the greateſt and moſt accurate Anatomiſts of this Age, *Malpighius*, *Bellini*, and *Nuck* have diſcovered. And indeed that all the Veſſels of the Body, in which the Liquors are continually moving, can have no other than a Cylindrical or Conical Form, is demonſtrable from the Nature of Fluids, whoſe Preſſure is always perpendicular to the Sides of the containg Veſſel, and equal at equal Heights of the Fluid: If therefore the ſides of the Veſſels are ſoft, and equally yielding every where (ſuch as are all the Tubes in the Body of a *Fœtus*) they muſt by the Preſſure of their contained Fluid, be equally every where diſtended; and conſequently the Section of ſuch a Veſſel perpendicular to its Axis muſt be a Circle, and therefore the Veſſel muſt be either a concave Cone or Cylinder, or at leaſt ſuch a Figure whoſe tranſverſe Section is a Circle.

The Circular Orifices therefore of the Glands can only differ in Magnitude, and all ſorts of Particles of a leſſer Diameter than that of the Orifice of the Gland may enter it; ſo that without ſome farther Contrivance, that Fluid which contains the biggeſt Parti-

cles,

cles, muſt likewiſe conſiſt of all the Particles of all the other Secretions; neither could any Fluid thicker than the Blood be ſeparated from it, becauſe of the great Proportion of the aqueous Fluid; whoſe Particles being vaſtly ſmaller than any other, and inviſible to the beſt Microſcopes, muſt enter all the Glands, and be mixt with the ſecerned Fluid.

How this Inconveniency may be prevented, and how the Particles of any ſize may either be ſeparated by themſelves, or with any aſſigned Proportion of the aqueous Fluid, or of other leſſer Particles, I ſhall now endeavour to ſhew.



Suppoſe A B to be a ſmall evaneſcent Artery, and that the Particles of the leaſt ſize were to be ſeparated from the reſt. From the ſide of the Artery muſt ariſe the Gland or Tube C K, whoſe Orifice at C is ſuch as is capable of admitting only Particles of the leaſt ſize, together with the aqueous Fluid; theſe therefore will be ſeparated from all the other Particles of the Blood, and the Tube C K being a Cylinder, they will paſs to its farther end K, which is ſuppoſed to be the excretory Duct of the Gland.

If the Quantity of the aqueous Fluid, ſeparated with the leaſt Particles muſt be diminiſhed, that ſuch a Fluid as is requiſite may paſs thro' the excretory Duct K, from the Tube C K, you muſt imagine that ſeveral

ral other ſmaller Canals go out as at D, E, F, G, whoſe Orifices are ſo ſmall, that they admit no other Particles beſides thoſe of the aqueous Fluid to paſs thro' them; and therefore as the leaſt Particles, together with the aqueous Fluid paſs along the Tube C K, the aqueous Fluid muſt conſtantly be diminiſhed, the Quantity of the leaſt Particles ſtill remaining, the ſame can paſs no where, but thro' the excretory Duct K; and this Diminution of the aqueous Fluid, will be always according to the Number of the Canals D, E, F, G, that is, in proportion to the Length of the Tube C K; and therefore according as the Gland is longer or ſhorter, ſo the more or leſs aqueous Fluid will paſs thro' the Orifice of the excretory Duct K, and conſequently the ſecreted Fluid upon this account be thicker or thinner.

If the Particles of a middle ſize, between the biggeſt and the leaſt, are to be drawn off from the reſt of the Blood; let the Orifice at the Gland C be juſt ſo big as to admit theſe Particles, and not any of thoſe that are bigger: Theſe Particles therefore, together with the aqueous Fluid, and all leſſer Particles will paſs thro' the Orifice C: But if the Canals D, E, F, G, are big enough to receive all the other Particles, and too narrow to admit the Particles that are to be ſeparated; it is evident, that thoſe Particles muſt arrive at the excretory Duct K, with what Proportion of leſſer Particles is required.

Thus

Thus we ſee how any ſort of Particles may be drawn off, either by themſelves or mixt with any others in any Proportion, and this is done in the moſt ſimple manner, only by Arteries; for C K is only a ſmaller Artery, ſtraight, ſpiral, or otherwiſe contorted; and D, E, F, G, are again Arteries ſmaller than it; and if any of theſe are ſo ſmall, as to admit only Particles of *Serum*, they conſtitute Lymphatick Veſſels; from thence it is that we find *Lympheducts* to ariſe in great Numbers from thoſe Glands that ſeparate thick Humours, as from the Teſticles, Liver, *&c.*

ESSAYS

ON

SEVERAL PARTS

OF THE

Animal Oeconomy.

ESSAY V.

Of Muſcular Motion.

A Muſcle is a bundle of thin and parallel Plates of fleſhy Threads or Fibres, encloſed by one common Membrane: All the Fibres of the ſame Plate are parallel to one another, and tied together at extremely little Diſtances, by ſhort and tranſverſe Fibres. The fleſhy Fibres are compoſed of other ſmaller Fibres encloſed likewiſe by a common Membrane: Each leſſer Fibre conſiſts of very ſmall *Veſicles* or Bladders into which we ſuppoſe the Nerves, Veins, and Arteries,

Arteries, to open; for every Muſcle receives Branches of all thoſe *Veſſels*, which muſt be diſtributed to every Fibre. The two Ends of each Muſcle, or the Extremities of the Fibres, are in the Limbs of Animals faſtened to two *Bones*, the one moveable, the other fixt; and therefore when the Muſcles contract, they draw the moveable *Bone* according to the Direction of their Fibres. When the Muſcles contract in Length, they ſwell in Thickneſs, as may be perceived by laying the Hand upon the *Maſſeter*, a Muſcle of the lower Jaw, and preſſing the Grinders together: But this Power of contracting or ſwelling is loſt when either the Artery or Nerve of the Muſcle is cut or tied; and therefore we conclude that the Contraction, Swelling, or Motion of the Muſcles is performed by the *Blood* and *Animal Spirits* diſtending the *Veſicles* or Cavities of the Fibres. This Diſtention of the *Veſicles* of the Fibres muſt be either by their being filled with a greater Quantity of *Blood* and animal Spirits than they were before the Contraction, or the *Blood* and Spirits mixing muſt rarify, and fill up a greater Space.

That the *Veſicles* of the Fibres are not diſtended purely by the Quantity of *Blood* and Spirits, will appear if we conſider, that were the *Veſicles* diſtended only by the Quantity of Fluids contained in them, Nature (whoſe Operations are always the moſt ſimple) had only uſed one Fluid and not two; for in the Works of Nature we no where find two neceſſary Cauſes where one could

 have

have produced the same Effect: Now how small soever we suppose the Quantity of Fluid brought by the Nerves to the Muscles, that alone might have contracted the Fibres (if a Quantity only of a Fluid had been requisite) by diminishing the Diameters of the Cavities or *Vesicles* of the Fibres, as will appear by the sequel of this Discourse. And as it is evident that the Reason why the Spirits alone do not distend the *Vesicles*, is not that there is not a sufficient Quantity for that purpose; so it will likewise appear that if there had not been a sufficient Quantity of the nervous Fluid, yet the quantity of Blood could have given no Assistance in the Distention of the *Vesicles*; for if the *Vesicles* contain a greater Quantity of *Blood* when the Muscles contract, than they do when the Muscles are relaxed, this Augmentation must proceed either from the *Blood*'s being stopp'd in the *Vein*, or it must move suddenly with a greater *Velocity* thro' the Artery into the Cavities of the Fibres. If the *Blood* is stopp'd in the *Vein*, it must be by the Contraction of its Coats, or by some external Pressure upon them: if by the Contraction of the Fibres which compose the Coats of the *Vein* the same Difficulty remains to be explained; for whatever is the cause of the Contraction of the Fibres of a *Vein*, will likewise serve to contract the Fibres of a *Muscle*. If the *Blood* is stopp'd in the *Veins* by a Pressure upon their Coats, it must be by the swelling of the Artery or muscular Fibres. If the Artery swells and presses on the *Vein*, the Circulation of the *Blood* must be entirely stopp'd; for that Pressure will constantly increase,

creaſe, the *Blood* being ſtill accumulated in the Artery; and therefore it will for ever hinder all Paſſage through the *Vein*: If it be ſaid that the *Blood* moving ſometimes with a greater *Velocity* through the Artery into the Cells or *Veſicles* of the Fibres, will diſtend them; this greater *Velocity* muſt proceed from the Force of the Heart, from which alone the Blood derives all its Motion: Now if the Heart acts with a greater Force, it will increaſe the Velocity of the Blood univerſally throughout the whole Body, and each Muſcle and its Antagoniſt will be thereby equally contracted, and conſequently neither will contract. And therefore being both the Blood and Fluid of the Nerves are neceſſary to the Contraction of the Muſcles, and being the contraction is not performed by the Quantity of theſe Fluids, it remains only that by their Mixture, they rarify and diſtend Veſicles.

Now for the explaining of this Rarifaction of the Blood and Spirits in the Veſicles of the muſcular Fibres, let us ſuppoſe a ſmall Globule of Air between the Particles of a Fluid, and that the Particles have a ſtrong attractive Force by which they endeavour to come together, they preſſing every way equally on the Globule of the Air, will hinder it from eſcaping any way from between them; but the force by which they endeavour to come together, being prodigiouſly greater than the Force of their Gravity, they will by this Force produce a very conſiderable Condenſation of the Globule of Air that lies between them; and the Force of Elaſticity being proportional always

to its Condenſation, the Force by which this airy Globule will endeavour to expand itſelf, will likewiſe be vaſtly great; and conſequently if by any means this Niſus of the Particles of the Fluid to come together ſhould be taken off, the Air between them would expand itſelf with a very conſiderable Force. Now if upon the mixing of another Fluid the Particles of the firſt Fluid ſhould be more ſtrongly attracted to the Particles of this other Fluid, than they were before to one another; then would their Niſus to one another ceaſe, and they would give the Globule of Air that is between them Liberty immediately to expand itſelf, and the whole Fluid would take up a greater Space than it did before. But when the Particles of the two Fluids come to be united together, they will again encloſe the Globule of Air that lies between them, and by their mutual Attraction ſoon bring it to its former State of Condenſation.

Now that the Blood contains a great Number of Globules of Air is evident from the Quantity it yields in the Air-Pump. And that the Particles of the Blood have a ſtrong attractive Force is likewiſe plain from what has been ſaid in the Theory of Secretion. By this Attraction of the Particles, the Globules of the Blood are formed; and in viewing the Circulation of the Blood with a Microſcope, I have ſometimes obſerved, that where the Diameter of the Canal has been leſs than the Diameter of a Globule of Blood, that the Globule would be preſſed into a Spheroidical Form, but when it came into a wider Part of the Canal again, it would immediately re-aſſume its former Figure; which I think

is

is probably owing to a ſmaller Globule of Air encloſed within, and expanding itſelf equally every way, when the Sides of its circumambient Shell of Blood, are not longer preſſed by the Sides of the Canal.

Theſe Globules of Blood continually circulating through the Veſicles of the Fibres (which are probably capable of containing only one Globule at a time) meet with the animal Spirits, which drop from the Nerves. Now the Minuteneſs of the Glands of the Brain, and the Smallneſs of the Fibres of the Nerves, plainly ſhew that the animal Spirits are a Fluid, conſiſting of the ſmalleſt Particles of any in the Body; and therefore their attractive Force muſt be the greateſt of all the Particles in the Blood, as is evident from what Sir *Iſaac Newton* has calculated about the Rays of Light; and conſequently the animal Spirits meeting with the Globules of the Blood in the Veſicles of the Fibres, and ſurrounding them, muſt attract the Particles of which they are compoſed, more ſtrongly than they do another; and conſequently their Niſus to one another ceaſing, the condenſed Globule of Air will expand itſelf with a very conſiderable Force, whereby each Veſicle of the Fibre will be diſtended, and conſequently the Fibre ſhortned, *i. e.* the whole Muſcle will be contracted. But when the Particles of the Globule of Blood are mixed with the nervous Fluid, they will both together encloſe the Globule of Air again, and compreſs it into as ſmall a Space as it was before; and thus the Contraction of the Muſcle muſt immediately ceaſe unleſs freſh Blood and Spirits ſtill ſucceeding

one another continue the Inflation of the Vesicles. But when a Muscle has been strongly contracted for some time, the Quantity of Spirits spent, being more than can be secerned in the same space of Time by the Glands which supply its Nerves, the Inflation of the Vesicles must fall, and the Muscle grow feeble and weak; whereas the Tonick Motion of the Muscles, being performed by the Spirits protruded only by the quantity last secerned in the Glands, will constantly continue without any Weariness.

After this manner I conceive the Vesicles to be distended without any Ebullition or Effervescence, and their Distention to cease without any Precipitation, or flying off of the aërial Globules through the Pores of the Muscles. For to this Attraction of the Particles of Matter is owing most of the Phænomena; for explaining of which Philosophers have been forced to have recourse to active and subtile Particles, which contrary to their own Principles they have made to move themselves every way, and to do whatever they had a mind should be done: But how these Particles came by so great an Activity was not at all to be accounted for from any of their Principles. Thus in explaining of Muscular Motion they make the animal Spirits to cut and pierce the Globules of Blood, and with their sharp Points to run them thro' and thro', that the imprison'd elastick Aura might be set at Liberty; which notwithstanding could not be effected, unless we suppose that Holes may be made in fluid Globules, as in a Board, and that the fluid Particles stand in a Heap, as the Waters of

of the Red-Sea did. And when the Aërial Globule is got loose, the Intumescence of the Vesicle cannot be asswaged, but by supposing the elastick Globules now to have Strength to break through the Muscles and Skin to come at the external Air, tho' before they had not Power nor Subtilty enough to get through a thin Shell of Blood.

But I come now to shew the Mechanism of the Fibres, or how excellently and wisely they are contrived for Contraction: It is a known Experiment that a Bladder when it is blown up and distended as to its Capacity, but contracted as to its Length, will by the Force of Contraction, raise a Weight to some determined height. And if two Bladders joined together and communicating with one another were blown up, the Weight would be raised by Inflation twice the Space that one alone would do it; because I suppose that both Bladders contract equally, and consequently the Contraction of both together will be double the Contraction of either. Three Bladders thus joined and distended will raise the Weight to triple the Height, and four to quadruple; so that if there were a String of Bladders joined together, of equal Bulk and like Figures, the space through which the Weight would rise, would be proportional to the Number of Bladders, or, which is the same thing, to the Length of the String.

Each Fibre of a Muscle consisting of a Multitude of small Vesicles, resembles a String of Bladders; and therefore the Contraction of the Muscle, is always proportional to the Length of its Fibres. And being the greatest Contraction

Contraction of the Fibres is always leſs than ⅓ of their Length (as ſhall hereafter be demonſtrated) there was a Neceſſity that the Inſertions of the Muſcles ſhould be near to the Joints, not only to increaſe the Velocity of the Parts moved; but likewiſe that they might deſcribe greater Arches round the Centers of their Motion: And hence it is that thoſe Parts which deſcribe the greateſt Arches, are moved by the longeſt Muſcles; as the Hand round the Elbow, which is bent by the *Biceps* ariſing from the *Scapula*; and the Foot round the Knee, which is bent by the Muſcles whoſe Originations are as far diſtant as the *Iſchium.* If theſe Joints had been moved by ſhort Muſcles inſerted at each end into the Extremities of the articulated Bones, the Arm and Leg had moved but a little way, and the Arches the Hand and Foot had deſcribed about theſe Joints, had been to the Arches they deſcribe now, as the Length of the ſhort Muſcles had been to the Length of the Muſcles they have now. On the contrary, where the Joints have but a ſmall Motion there the Muſcles are ſhort: Thus we find that the Fingers are pulled ſide ways bythe *Interoſſæi*, the Thigh is drawn outwards, and obliquely by the *Quadragemini* and *Obturatores*, which are all ſhort Muſcles, and moſtof the Muſcles of the *Vertebræ* run between one *Vertebra* and the next. From hence it is evident that the Originations and Inſertions of the Muſcles, are every where the beſt that could be contrived.

The Veſicles of which the Fibres conſiſt are extremely ſmall; for tho' one large Bladder may raiſe a Weight as high as ſeveral ſmall ones, yet

yet the Quantity of Elastick Fluid used in the Inflation, together with the swelling of the large Bladder, will be much greater than when a Weight is raised by a String of small ones. For suppose two Bladders of similar Figures, but the Diameter of the one triple to the Diameter of the other, then will the one require twenty-seven times the Quantity of Elastick Fluid to expand it that the other does, and it will swell to twenty-seven times the Space; and yet three of the lesser Bladders joined together, will raise the Weight to the same Height that the bigger one does, but with nine times less Expence of Elastick Fluid and they will take up but one ninth Part of the Space. By diminishing therefore the Bigness of the Vesicles, and increasing their Number, the Force required to distend the Vesicles, and the Distention itself, may be diminished in any given Proportion, and come at last to be insensible. Suppose a Bladder of a determined Bigness can raise a Weight a Foot; a hundred Bladders whose Diameters are each $\frac{1}{100}$ part of the former being blown up, will raise the Weight to the same Height, but the Force of Inflation, and the swelling of all put together, will be ten thousand times less than in the large one.

If a Weight of a determined Bigness can be raised to a certain Height by one Bladder, or one String of Bladders, to which the Weight is tied; twice that Weight may be raised by two such Bladders, or Strings of Bladders, and triple that Weight by three such Strings. And consequently the Weight a Muscle can raise, will be always as the Number of its Fibres,

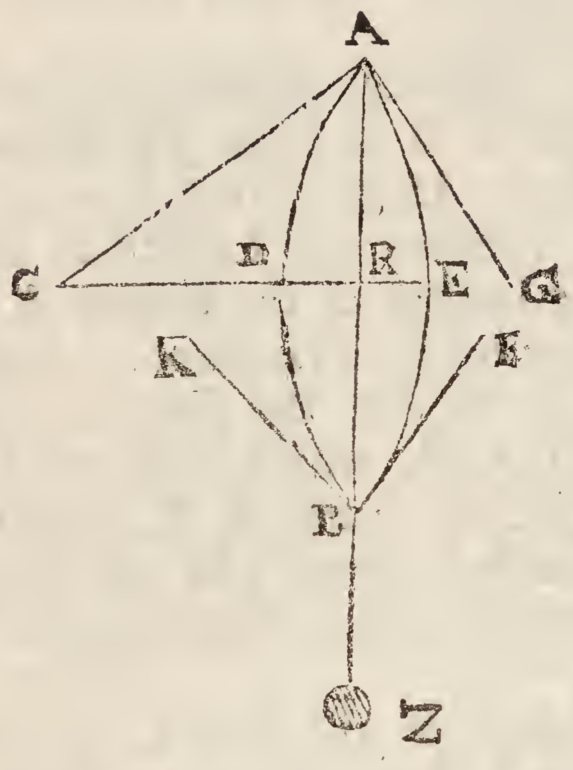
bres, that is, as its Thicknefs, fuppofing the Diftention of the Veficles equal. And the abfolute Strength of one Mufcle is to the abfolute Strength of another, as their Bulks.

It is to be obferved that in determining both the Contraction and Strength of a Mufcle, no Regard is to be had to the Tendons; becaufe in them we obferve no Inflation, and we find Nature no where making ufe of a Tendon, but where either there was not room for the Infertion of fo many flefhy Fibres, or where it was neceffary the Mufcle fhould draw from fuch a Point.

I fhall in the next Place determine the Force of the Elaftick Fluid neceffary to diftend the Veficles fo as to raife to a determined Height any given Weight. But before this can be done, the Figure that each Veficle will be formed into by the Force of the Elaftick Fluid diftending it, muft be found out: And therefore let us conceive each Veficle to confift of an infinite Number of Threads, whofe Ends are faftened by tranfverfe Ligaments; and from hence it follows that if a diftended Veficle were cut with a Plain thro' its Axis, the Curve of the Section will be the fame with that of a Thread whofe two Ends are faftened, and the whole preffed by an Elaftick Fluid; and becaufe Elaftick Fluids endeavour to expand themfelves every way, and all Fluids prefs perpendicularly on each Obftacle, it is evident that the Thread muft be every where equally and perpendicularly preffed, and therefore its Flexion or Curvature muft be every where equal and fimilar, and confequently the Thread muft be formed into a circular Arch.

Hence

Hence it follows that the whole Section of the Vesicle consists of two equal and similar Arches, whose common Subtense is the Axis of the Vesicle. Suppose now A E B and A D B to be the two circular Arches, C the Center of the Arch A E B, A G and B F Tangents in the Points A and B, Z the Resistance to be raised. The Angle C A G or C A E is equal to a right Angle = to C A R + A C R, and therefore the Angle A C R = G A R, or E A R = E B R = D B R; and therefore the Arch E A or E B is the Measure of the Angle E A R, or E B R, and the Space through which the Resistance Z is raised, is equal to the difference between the Arch A E B and its Chord A R B, or



equal to twice the difference of the Arch A E and its Sine A R; which having the Arch A E,

A E or the Angle E A R given in Degrees and Minutes may be easily calculated. But to do this the Length of the Radius A C must be determined in such Parts, whereof 100000 make up the Arch A E, which is done thus. The Degrees of a circular Arch, whose Length is equal to the Radius of the Circle is 57° 295; and therefore the Degrees in the Arch A E is to 57° 295, the Length of the Radius expressed in Degrees as 100000, the parts of which the Arch A E consists, to the Radius expressed in the same Parts, which will therefore be given. And again, as the Tabular Radius is to the Tabular Sine of the Arch A E, so is the Radius A C (which is already found) to the Sine A R, which will likewise be found. This being substracted from A E and the Remainder doubled, is the Elevation of the Weight Z.

Thus for Instance, suppose the Arch A E or the Angle E B R to be 30 Minutes, say, as $30'$, or half a Degree, that is $\frac{5}{10}$ is to 57° 295, so is 100000 the Length of the Arch A E, to the Length of the Radius A C which will be found to be 11459000. And again, as 100000 is to 872 the Sine of $30'$, so is 11459000 to A R, which is therefore 99906, which substracted from A E, and the Remainder doubled, gives 186 the Sublevation of the Weight Z in such Parts whereof A E is 100000.

The Tension of the Fibre, or the Force wherewith it is stretch'd by the Resistance Z, may be thus determined. The Tension of the Fibre, or the force sustaining the Weight in the Point B, is the same as if the Weight Z were

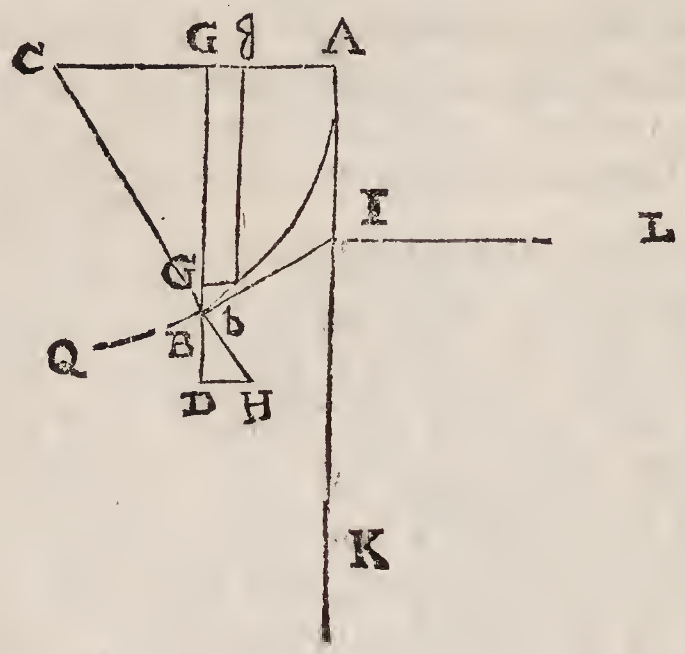
were ſuſpended by two Threads touching the Arches in the Point B, and in that Caſe the Tenſion of the Thread B F is to the Weight Z, as the Sine of the Angle F B R or E B R is to the Sine of the Angle F B H or E B D; (*a*) and conſequently the Tenſion or Firmneſs of the Thread will be $= \frac{Z \times \text{Sine } EBR}{\text{Sine } EBD}$.

Now call the abſolute Force of Expanſion that the elaſtick Fluid muſt have to raiſe a given Weight to a determin'd Height *n*; the Preſſure on any part of the Thread will be as the Force of Expanſion of the Fluid, and the Portion conjunctly; for if the Portions of the Thread be taken equal, the Preſſures on them will be as the Force of Expanſion, or the Elaſticity; and if the Force of Expanſion be the ſame, the Preſſure is as the Portions on which it preſſes: and therefore univerſally it is as the Force of Expanſion and the Portion jointly, or as the Product of the two.

Let A B repreſent the circular Thread, B b an indefinite ſmall Portion of the ſame, and the Preſſure on B b will be $n \times Bb$, which ſuppoſe equal to B H: The Preſſure B H can be reſolved into two Forces, one whereof is as D H acting horizontally, or according to the Direction D H, and the other at B D acting vertically, or according to the vertical Direction B D; and becauſe of the equiangular Triangles G B b and B D H B G : D H : : B b : B H : : B b : $n \times$ B b (: : 1 : *n*) : : G b : B D; therefore

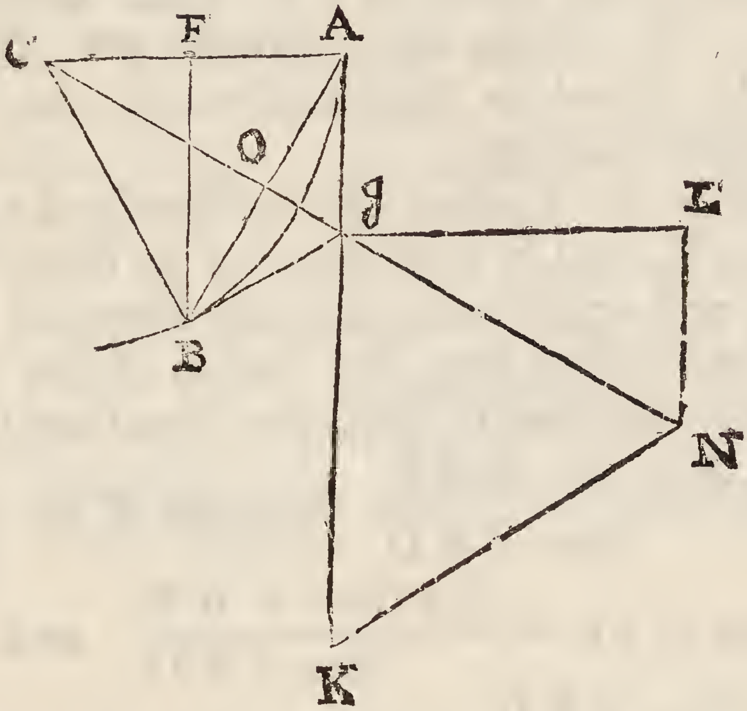
(*a*) *By the 2d cor. prop.* 33 *of the* Lectiones Phyſicæ Jo. Keill.

D H $= n$ B G, and B D $= n$ G b, and therefore the Sum of all the horizontal Forces will be equal to n multiplied by all the B G's, that



is n multiplied by B F $= n \times$ B F, and the Sum of all the vertical Forces is equal to n multiplied by all the G b's, that is $= n$ A F. Now it is plain that the Tenſion of the Fibre in the Points A and B is the ſame with the Tenſion of two Threads Tangents in the Points A and B (where they are ſuppoſed to be faſtened) that are drawn at their Point of Concourſe I, by all the horizontal Forces according to the Direction I L, and by all the vertical Forces according to the Direction I K: And therefore to determine the Tenſion of the Fibre, the Tenſion muſt be determined of the Threads that are pulled at the Point I by a Force n F B, according to the Direction I L, and by a Force n F A according to the Direction I K. Take I L $= n$ F B and L N perpendicular to it $= n$ F A, and the two Forces I L and L N will

will be equipollent to a third Force as I N, acting according to the Direction I N, and therefore the Threads will be stretched to the same Degree by the Force I N that they would be by the two Forces I L and L N and because I L (n B F) : L N (n F A) : : B



F : F A, and the Angles at L and F equal (by the 6th of the 6th) the Triangles B F A and I L N will be equiangular, and the Side I N will be equal to n B A, and the Angle F A B = L N I = (by 29. 1.) A I O, add the Angle I A O to both, and the right Angle F A I will be equal to A I O + I A O = (32. 1.) A O C; and therefore because A I = I B, and the Angles at A and B equal, the Angle A I O must be = B I O and A O = O B, the Line therefore N O cutting the Line A B equally and at right Angles must pass through the Center. Through N draw N K parallel to B I, meeting with A I produced in the

 Point

Point K, then the Forces by which the Threads are ſtretched will be as I K and N K, * the Angle K I N = A I O = F A B = B I O = I N K. The Triangle therefore K I N is an Iſoſceles Triangle, and equiangular to the Triangle A B C, and A B : A C :: N I : I K :: *n* A B : *n* A C; and therefore I K or K N will be equal to $n \times$ A C, that is the Forces by which the Threads are ſtretch'd will be equal to the Radius of the Circle multiplied by *n*.

Hence the Tenſion of the Fibre in the Points A and B, and ſo in all other of its Parts, is the ſame and equal to the abſolute Force of Elaſticity multiplied into the Radius of the Circle. But the Tenſion of the Fibre was found before to be $\frac{Z \times \text{Sine } EBR}{\text{Sine } EBD}$, therefore if we call the Radius r. $nr = \frac{Z \times \text{Sine } EBR}{\text{Sine } EBD}$ and $n = \frac{Z \times \text{Sine } EBR}{r \times \text{Sine } EBD}$ and $r \times$ Sine E B D will have the ſame Proportion to the Sine E B R as Z to *n*. Hence it is plain that no finite Force of Elaſticity can extend the Fibre A E B D to a complete Circle, for in that caſe the Sine of the Angle E B D being nothing $r \times$ Sine E B D is nothing, and therefore Z will be to *n* as nothing to ſomething, or as a finite to an infinite.

The greateſt Contraction of the Fibre that can be, muſt always be leſs than 72728 of ſuch

* Keil's Lectiones Phyſicæ, *Prop.* 33.

Parts whereof the Arch A E is 100000, for if the Threads were extended into complete Circles, the Contraction would be only $\frac{72728}{100000}$ of A E, which it can never arrive to; therefore the Contraction must be always less than $\frac{1}{3}$ of the Length of the Fibre: It is also plain that when the Angle E B R is small, the Force of Elasticity bears but a small Proportion to the Resistance. For Example when the Angle E B R is but 30′ the Radius or *r* multiplied into the Sine of the Angle E B D the Sine of one Degree, is to the Sine of the Angle E B R the Sine of 30′ as Z to *n*, that is, $r \times 1745 : 872 :: Z : n$, that is $Z : n :: 11459000 \times 1745 : 872 :: 19995955000 : 872 :: 22931141 : 1$, and consequently a small Degree of Elasticity will produce a prodigious Energy in the Muscles.

MEDICINA STATICA BRITANNICA:

OR

STATICAL

Obſervations and Experiments

Made in *ENGLAND.*

By *JAMES KEILL*, M. D.

Explained and compared with the Aphoriſms of *SANCTORIUS.*

By *JOHN QUINCY*, M. D.

LONDON:

Printed in the Year MDCCXXXVIII.

TO THE LEARNED

JOHN FREIND,

Doctor of Physick.

Dear Sir,

THAT you may not think me guilty either of Negligence or Forgetfulneſs, I ſend you theſe papers, according to my promiſe, to be committed either to darkneſs or light at your pleaſure: nor am I at all ſollicitous which way you ſhall think fit to diſpoſe of them; for who can

blame me for what is done according to your opinion? My reputation will be ſafe, if you act conſiſtently with your own dignity; if you involve them in darkneſs, which, in my opinion, they deſerve, you will neither diſoblige me, nor injure any one: but if you think them worthy of the light, how little uſeful ſoever they may be, very little indeed in my own opinion, yet they will be eſteemed and valued, as being thought fit to be publiſhed by one, whom all readily allow to be the greateſt Maſter of writing and teaching, in our own Nation at leaſt, perhaps in all others. The praiſe and ornament of a Phyſician is Genius; of Genius light, and a ſtrength and copiouſneſs of expreſſion: you, by the ſtrength of your Genius, have diſcovered Nature lying hid in the boſom of darkneſs, by the force of your reaſon have brought it into

light,

light, and adorned and illuſtrated it with an extraordinary elegance of ſtyle. With what talents you firſt began to practiſe was well known to me: and with what ſkill you now proceed, all the learned, and the numerous crowds of thoſe whom you have reſtored to health teſtify. That you are perfectly acquainted with the Animal Oeconomy, abundantly appears from what you have ſaid in your *Emmenologia.* That the powers of nature and the efficacy of Drugs are known to you, as formerly to Æſculapius, your Chymical Lectures declare. And how diſcerning you are in the natures of Diſeaſes is ſhewn in your elegant Commentaries on the Father of Medicine, which I have read over and over with the greateſt pleaſure. In them you have quite exploded that ill grounded rule of Art, of not purging in the Secundary Fever of the Small Pox, and by a happier

method

method of practice have ſaved many from the jaws of death. How ſucceſsful Purging is in that ſtage of the Diſeaſe, I had the pleaſure lately to ſee in a youth of a noble family ſnatched from the very confines of Death by our joint advice; and have often experienced during the run of that diſtemper now for two years thro' our town, In which method of practice that there is leſs danger than was commonly believed, I firſt ſuſpected rather accidentally, than by any force of reaſoning. For when a Woman in the moſt confluent ſort of the Small Pox, on the eleventh day of the eruption, by a great negligence of the Nurſe, had taken a purge inſtead of an opiate, by which means ſhe had ſeven fetid, and quite purulent ſtools, ſhe, who before was in the greateſt danger of loſing her life, in three days time was quite out of danger. The Puſtules, which were

fluxed

fluxed on her limbs, being void of matter, had the appearance of small flaccid bladders; so far is the depression of the pustules, from bringing any inconvenience at that time, that the return of the purulent matter into the Blood, and the ejection of it by stool, saved her life. No Physician surely, who attends the course and nature of the disease with such judgment as you, can object to what you have said. For on the first days of the distemper all nature is in a ferment to throw off the offensive matter from the Blood, and expel it thro' the cutaneous pores. That these parts are by Nature delegated to the Fever, is manifest from this, that in all kinds of the Small Pox, the Fever recedes as this extermination of the humour proceeds; in that worst sort, where hardly any thing is thrown off, from the beginning to the end of the Tragedy, the Fever always rages;

rages; but in the good ſort, where the Puſtules ſwell with a copious eruption of the noxious matter, the Fever goes quite away, as having already performed it's office. But afterwards, when the concocted humour of the Puſtules ſeems too thick to be evaporated, being again reſorbed by the Blood Veſſels, it raiſes new tumults, and brings on the *Secondary* Fever, which muſt be extinguiſhed in the ſame manner as the Primary one, by getting out the retracted matter. In this ſtate of affairs, you have rightly judged, *that there is no way left, of performing this neceſſary work, but by gentle and continual purging, which both reaſon and experience confirm may be done without any danger of life.* That this faculty of abſorbing the humour thro' the ſkin was not unknown to Hippocrates, you, Learned Sir, well know, and is evidently proved by the Obſervations, which

in obedience to your commands I now ſend you. Whoſoever ſhall make an equally happy diſcovery of the manner of ſeparating the humour from the Blood at the beginning of the diſeaſe, will ſeem to me to have brought the cure of the diſtemper to perfection; for when nature has got a matter duly prepared, and fitted for expulſion, it will always be able to throw it out by it's own ſtrength, or with very little aſſiſtance; and when all the peccant matter is thrown out, the diſeaſe generally proceeds to it's ſtate without any ill accident. On this preparation therefore of the humour all the ſucceſs of the cure chiefly depends; and all ingenious perſons ought to labour in tracing it out: this would be worthy of you, Sir, on whom all have now caſt their eyes. Proceed therefore to ſuſtain that character, which you have already gained, and to ſatisfy the

the expectation which the world has of you, and purſue thoſe ſtudies in which you are ingaged, to your own honour, the benefit of the Sick, and the glory of Phyſick. I am

SIR,

Your moſt humble Servant

Northampton,
May 24, 1718.

JAMES KEILL.

THE

PREFACE.

T*HE celebrated* Sanctorius *always was and always will be applauded in every age of Learning, for having first discovered, and brought to perfection the way of measuring* insensible Perspiration. *Those Aphorisms which he drew up for the use of his own Countrymen have been received by the Physicians of other nations as universal Axioms. But what difference there is between the Italians*

Italians and the Engliſh, will appear from the following Tables; which contain a ſeries of Obſervations for a whole year, and ſome others made at leiſure times in a ſpace of ten years. The truth of the Aphoriſms is involved, and the weight of the reaſonings depends on Obſervations unknown to the Reader. But whoſoever looks over the Tables, will be as it were preſent at the Experiments, and will ſeem to be made his own judge of the truth of the Aphoriſms. He may alſo draw other more uſeful Obſervations from them, which eſcaping in the Aphoriſtical way of writing, would have lain hid in perpetual darkneſs. But that I might not ſeem to impoſe too great a labour on the Reader, I have thought it proper to collect ſome undoubted Aphoriſms, and thoſe the moſt obvious: if theſe do not anſwer his expectation, it may not be diſagreeable to him to look over the Tables, and by comparing one day with another,

another, to pick out what he pleaſes. The Thermometer made uſe of is divided into 105 *equidiſtant degrees, numbered from the top downwards, and the* temperate *ſtate of the air is at the forty fifth degree. Moſt of theſe Experiments were made between the age of thirty and forty, in which ſpace of time the courſe of the Experiments was never intermitted on account of any diſorder, except a Nephritic complaint, which never retarded the Urine, as it often does in others. Perhaps there may be other proportions between the Urine and Perſpiration in other Conſtitutions; that which is here tried is moiſt and warm. Other things relating to the* Animal Oeconomy *may certainly be found out by weighing; but as they require a conſtant and certain way of living, a man of buſineſs cannot find leiſure to purſue them with ſufficient diligence.*

JULY.

Day of the Month.	Hour of the Morning	Barom.		Therm.	Morning Weight.		Night Urine.		Night Persp.	
					℔	℥	℔	℥	℔	℥
2		29	5							
3	9	29	4		154	01¼	00	10	00	14
4	10	29	3		153	9½	00	15	00	15
5	7	29	4	36	153	6	00	15	00	11
6	7	29	6	34	152	6	00	14	00	11
7	8	29	9	34	152	11½	00	6½	00	9
8										
9	9	29	9	26	153	2⅓	00	12¼	00	12
10	7	29	8		153	2½	00	5½	00	12
11	7	29	5	26	153	0½	00	9½	00	13
12										
13	11	29	4	26	151	12	00	15	00	15
14	9	29	3	30	152	11½	00	15½	00	12
15	10	29	5	31	153	9	1	4	00	12
16										
17	9				153	15	1	2	00	10
18	9	29	4	39	154	4½	1	2½	00	12
19	9	29	7	35	155	1½	0	15½	00	14
20	9	30	1	31	154	10½	1	0½	00	12
21	8	29	7	30	154	4	1	00	00	12
22	8	29	5	30	154	11	0	11	0	11
23	10	29	5	28	154	7	0	13	0	12
24	10	29	5	24	154	10	0	12	1	02
25	9	29	5	26	155	4	0	10½	0	10½
26	9	29	3	31	156	8	0	12	1	4
27	10	29	4	33	156	8	1	03	0	11
28	7	29	4	35	155	11	1	06	0	5
29	8	29	4	34	154	9	0	13	0	10
30	10	29	5	33	153	8	0	10	0	6
31	9	29	5	33	154	14	0	10	1	0

Hour

Hour of the Night.	Barom.		Therm.	Night Weight.		Meat and Drink.		Day Urine.		Excrem.		Day Persp.	
				℔	℥								
12	29	5		155	9¼								
12	29	2		155	7½								
12	29	4		155	0								
12	29	5	34	153	15								
12	29	9	32	153	11								
12	30	1	22	154	11								
12	29	9	22	154	4								
12	29	5	23	154	7								
12	29	4	26	153	10								
12	29	3	27	154	7	5	6	1	1	0	4	1	6
12	29	2	33	155	9								
12	29	5	33	155	11								
11	29	3	36	156	3								
11	29	4	35	156	15								
12	30	1	31	156	7								
11	29	7	28	156	0	4	10½	1	12½	0	5	1	03½
11	29	7	27	156	1	4	11	0	12	0	7	1	11
12	29	5	28	156	0								
11	29	5	25	156	8								
11	29	5	24	156	9								
11	29	3	29	158	8								
12	29	3	31	158	6								
11	29	4	33	157	6	4	1	1	12	0	4	1	3
11	29	5	32	157	0								
12	29	5	32	154	8								
12	29	4	31	156	8								
12	29	5	31	158	8								

Day of the Month.	Hour of the Morning.	Barom.		Therm.	Morning Weight.		Night Urine.		Night Persp.	
1	8	29	5	34	157	6	0	8 ½	0	9 ½
2	9	29	5	33	156	6	0	12 ½	0	11 ½
3	8	29	4	32	155		0	11	0	13
4	10	29	7	38	151	12	0	10	0	13
5	8	29	5	36	153	1	0	7 ½	0	8 ½
6	10	29	5	36	153	14	0	9 ½	0	12 ½
7										
8	9	29	3	40	155	10	0	12	0	8
9	9	29	5	39	153	14	1	4	0	6
10	9	29	6	37	153	2	0	10 ½	0	9 ½
11										
12										
13	8	29	7	37	152	6	0	9	0	9
14	9	29	7	37	154	6	0	10	0	10
15	7	29	6	33	154	8	0	10	0	14
16										
17	9	29	8	31	154	0	0	14	0	12
18	6	29	7	37	154	14	0	9	0	5
19	8	29	7	39	153	6	0	11 ½	0	8 ½
20	6	30		37	152	7	0	10 ½	0	9 ½
21	8	29	9	35	152	6	0	9	0	9
22										
23	9				153	2	0	8 ½	0	11
24	8	29	9	33	153	12	0	10	0	8
25										
26										
27	10	29	8	27	150	9	0	9	0	12
28	9	29	7	29	152	3	0	11 ½	0	12
29										
30	9				154	8	0	11	0	11

Hour

AUGUST.

Hour of the Night.	Barom.	Therm.	Night Weight.	Meat and Drink.	Day Urine.	Excrem.	Day Persp.	Wind.
12	29 5	31	157 12					N E
12	29 5	33	156 8					N E
11	29 6	35	153 3	3 13 ½	0 14	3 9 ½	1 3	N E
11	29 7	35	154 1					
11	29 5	34	155 4	6 5	1 4 ½	1 2	1 11 ½	W
								W
11	29 3	37	156 14					W
10	29 4	37	155 8					W
11	29 6	36	154 6					W
								N
10	29 7	33	153 8					
11	29 8	36	155 10					
11	29 8	31	156 0					N
								NW
10	29 8	33	155 10					
11	29 6	33	155 12					
12	29 8	37	154 10					W
10	30	36	153 11	4 4 ½	1 12	0 8	1 11 ½	W
12	29 9	35	153 11					NW
11	30	30	154 6					
11	30	29	154 14					
12	29 8	24	151 14					
11	29 8	24	153 12	5 1	0 13 ½	0 3	0 13 ½	W
11	29 8	28	155 14					

Day

SEPTEMBER.

Day of the Month.	Hour of the Morning.	Barom.		Therm.	Morning Weight.		Night Urine.		Night Persp.	
1										
2	10	29	3	38	152	6				
3	9	29	5	42	152	11	0	10½	2	5¾
4	9	29	7	42	153	7	0	8½	0	8½
5	7	29	7	41	154	11	0	8½	0	10½
6	9	29	7	41	154	11	0	12	0	6
7	9	29	7	36	154	8	1	1½	0	10½
8	8	29	7	31	153	6	0	14½	0	11½
9										
10	9	29	2	34	153	7½	0	10½	0	11
11	8	29	0	37	154	13½	0	13	0	11½
12	7	29	3	41	155	0	0	12¾	0	10¼
13	8	29	5	41	156	7	1	2	0	8½
14	11	29	5	39	154	10	1	0¾	0	11¾
15	8	29	4	44	153	3	0	9¾	0	7¼
16	9	29	2	45	155	00	1	0½	0	12
17	9	29	3	47	155	11	0	14¾	0	11¾
18	7	29	4	52	155	1	0	9¾	0	8¾
19	10	29	6	46	153	12½	1	1	0	13½
20										
21	9	29	2	49	153	7	0	13	0	13
22	8	29	5	47	154	6½	0	13½	0	9½
23	8	29	7	45	153	12	0	15	0	9
24	9	29	5	47	153	10	0	12¼	0	9¾
25	8	29	5	49	154	6	0	13¼	0	5¾
26	9	29	6	50	155	7½	0	13¾	0	11¼
27	8	29	5	52	154	14½	0	14	0	6
28	8	29	4	52	154	12	0	9¾	0	13¾
29	9	29	5	55	155	7	1	4	0	9
30										

Hour

SEPTEMBER.

Hour of the Night.	Barom.	Therm.	Night Weight.	Meat and Drink.	Day Urine.	Excrem.	Day Persp.	Winds.
11	29 4	38	155 4	5 2	0 14½	0 8	0 13½	N
12	29 6	41	154 8	8 2	1 0½	3 8	1 12½	N
11	29 8	40	155 14					NW
11	29 7	39	155 13					N
12	29 7	35	156 4					E
12	29 8	31	155 0	4 6	1 12	0 3	1 15	SW
11	29 2	32	154 13					SW
10	29 1	34	156 6	5 2½	0 13¾	0 1	1 5¾	SW
11	29 2	38	156 7					N
11	29 5	39	158 1½					N
12	29 6	41	156 6½					E
11	29 3	41	154 4	2 13½	1 4½	0 7½	1 7½	W
11	29 4	42	156 12½					W
11	29 3	43	157 5½					NW
10	29 4	46	156 3½					N
11	29 6	47	55 11					N E
								S W
12	29 3	45	155 1					NW
11	29 3	49	155 13½					N
11	29 6	45	155 4	3 13	1 8	0 6	1 1½	N
12	29 7	45	155 0	3 14	1 3	0 3	1 4	N E
12	29 5	48	155 9	4 11	1 7½	0 0	1 4	N E
11	29 5	50	157 0½					NW
12	29 6	50	156 2½					
12	29 5	50	156 3½					NW
11	29 6	50	157 4					S W
								NW

Day

OCTOBER.

Day of the Month.	Hour of the Morning.	Barom.		Therm.	Morning Weight.		Night Urine.		Night Persp.	
1										
2										
3										
4	8	29	5	51	156	1 ½	0	10 ½	0	11 ½
5	8	29	7	49	155	12	1	5	0	8
6	9	29	7	49	154	13	0	15	0	9
7	10	29	7	53	155	5 ½	0	12 ½	0	7 ½
8	9	29	8	53	156	13	1	00	0	10
9	8	29	9	55	155	12	0	13	0	6
10	8	30		58	155	2	0	13	0	10
11	8	30	1	57	154	15 ½	0	9 ¼	0	7 ¾
12	8	30	1	56	155	9	0	10 ½	0	6
13	9	30		56	154	14	0	10 ½	0	9 ½
14										
15	8	29	7	54	155	8 ½	0	10	0	10
16	9	29	7	54	156	12 ½	1	3 ¼	0	8 ¼
17	8	29	9	55	156	3	0	14	0	8
18	9	29	9	54	156	1	1	4 ½	0	9
19	9	29	8	55	155	3	0	13	0	9 ½
20	9	29	8	54	154	15	0	11 ¾	0	9 ¾
21	8	29	7	57	156	5	0	10	0	7
22	9	29	6	59	154	12 ½	1	1 ¼	0	11 ¼
23	9	29	7	56	156	8 ½	0	11 ¼	0	14 ¾
24	9	29	6	57	157	3	0	11 ½	0	8 ½
25	9				157	4	1	00	0	9
26	8	29	7	51	156	14 ½	1	5 ½	0	9
27										
28	8	29	7	51	156	9 ¼	0	10 ¾	0	8 ½
29	9	29	4	51	156	8 ½	0	14	0	8 ½
30	8	29	3	54	157	1 ½	0	12	0	7
31	9	29	4	54	156	14 ½	0	12 ¾	0	8 ¼

Hour

Hour of the Night.	Barom.		Therm.	Night Weight.		Meat and Drink.		Day Urine.		Excrem.		Day Persp.		Winds.
11	29	4	49	157	7½									
12	29	7	47	157	9									
11	29	6	49	156	5									W
12	29	7	51	156	9½									SE
11	29	8	51	158	7									N
12	29	9	53	156	15									N
11	30		56	156	9									E
11	30		56	156	0½									E
11	30	1	55	156	9½									E
11	30	1	54	156	2									NE
														NE
11	29	8	55	156	12½									NE
11	29	6	54	158	8									NE
12	29	8	54	157	9									NE
11	29	9	54	157	14½	4	15½	2	2¼	0	5	0	12¾	NE
12	29	8	54	156	9½	4	0	2	0	0	3	1	7½	NE
11	29	9	53	156	4½	4	4½	1	11¾	0	7	1	0¼	NE
11	29	7	55	157	6									NE
11	29	0	57	156	9									W
11	29	7	57	158	2½									NW
12	29	6	55	158	7									SW
12	29	8	54	158	13	4	11½	1	10½	0	2½	1	4½	SW
11	29	9	49	158	13									SW
11	29	7	51	157	12½									SW
12	29	6	49	157	15	3	12½	1	5¼	0	4½	1	12⅓	SW
11	29	3	51	158	4½									NW
11	29	3	53	158	3½	4	1¼	1	5¾	0	5	1	4½	NW
11	29	5	58	158	11									NW

NOVEMBER.

Day of the Month.	Hour of the Morning.	Barom.		Therm.	Pulses in Min. 1.	Morning Weight.		Morning Urine.		Night Persp.	
1	10	29	7	56		156	11 ½	1	8 ½	0	7
2	9	29	8	54		156	5	1	2 ½	0	8 ½
3	8	29	8	54		157	6	0	13	0	9
4											
5											
6	9	30	1	57	80	156	4	0	13	0	9
7	9	30		57	72	156	1	0	12 ¼	0	8 ¼
8	8	29	8	63	80	155	7	0	8	0	6 ½
9	9	30		65	80	155	14	1	5 ½	0	7 ½
10	10	30	1	65	72	155	14 ½	0	12 ¾	0	10 ¼
11	9	30	2	63	80	156	4	0	11	0	8
12	9	30	1	61	80	156	2	0	13 ¼	0	8 ¾
13	8	30	1	60	76	156	12	0	12 ¾	0	7 ¼
14	9	29	9	61	80	155	12 ½	0	9 ½	0	8 ½
15	9	29	9	56	76	156	14	0	12 ¾	0	8 ¼
16	8	29	9	63	80	155	11 ½	0	10 ¾	0	7 ¼
17	7	30		65	88	157	1	0	11	0	5
18											
19	9	29	5	66	80	156	3	1	2 ¾	0	12 ¾
20	9	29	6	70	80	155	8	0	11 ¼	0	6 ¼
21	10	29	7	68	80	155	12	0	14 ½	0	11 ½
22	10	29	5	65	84	156	3 ½	1	4 ¾	0	11 ¼
23	9	29	1	65	84	156	11	0	15 ¼	0	9 ¼
24	9	29	1	65	80	154	9	0	11	0	7 ½
25	9	29	4	65	80	154	12 ½	0	9 ¼	0	6 ¾
26	9	29	5	65	80	154	12	0	12 ½	0	7 ½
27	10	29	6	66	80	153	12 ½	0	13 ¼	0	8 ¼
28	9	29	5	67	76	154	12	0	9	0	8 ½
29	8	29	5	71	76	156	1 ½	0	12	0	7 ½
30	9	29	7	62	76	154	7 ½	1	0 ¼	0	9 ¾

Hour

NOVEMBER.

Hour of the Night.	Barom.		Therm.	Pulses in Min. 1.	Night Weight.		Meat and Drink.		Day Urine.		Excrem.		Day Persp.		Winds.
11	29	9	54		158	0									N W
11	29	8	52		158	12									N W
															N
11	30	1	56	80	157	10									N
11	30	1	57	70	157	5½									
1	29	9	57	80	156	5½	3	13½	1	14½	0	0	1	10½	N
11	29	9	63	85	157	11									N
10	30	1	63	80	157	5½	4	11	1	13	0	5	1	1½	W
12	30	2	63	76	157	7	4	3	1	7¼	0	0	1	3¼	W
11	30	2	61	80	157	8	5	8	2	6½	0	5	1	8	W
11	30	2	59	80	158	0	4	8½	1	12¼	0	0	0	14¼	N
12	30		61	84	156	14½									W
11	29	9	58	80	158	3									W
12	29	7	60	80	156	13½									N W
12	30		63	80	158	1									N W
11	29	5	63	80	158	2									N W
12	29	5	69	80	156	9½									N W
12	29	7	68	80	157	6									
11	29	6	64	94	158	3½									S
11	29	4	64	94	158	3½									S W
11	29	1	65	88	155	11½	2	11½	1	11¼	0	7½	1	7¼	N
12	29	3	65	72	155	12½									N
12	29	5	64	84	156	0	3	10½	1	2	0	0	1	5	N
11	29	5	65	96	155	2	3	6	1	5	0	3½	1	7	N
12	29	6	66	80	155	13½									N
11	29	5	68	68	157	5									N
11	29	8	65	88	156	1½									S
11	29	6	58	80	156	0	4	7½	1	3¼	0	2	1	9¾	W

DECEMBER.

Day of the Month.	Hour of the Morning	Barom.		Therm.	Pulses in Min. 1.	Morning Weight.		Night Urine.		Night Persp.	
1	9	29	4	58	80	154	9	0	13¾	0	9¼
2	10	29	3	63	72	154	5	0	12	0	9½
3	9	29	3	58	72	154	10½	0	11	0	7½
4	10	29	2	62	72	156	1½	0	14	0	11½
5	8	29	2	63	80	155	15	0	11¼	0	7¾
6	10	29	1	58	76	157	3	0	11¾	0	9¼
7	9	28	9	63	72	156	0	0	10	0	9
8	9	29	3	61	80	155	15	0	13	0	9
9	9	29	3	61	76	156	6½	0	12¾	0	8¾
10	8	29	3	60	80	156	8	0	8	0	8
11	9	29	4	60	88	155	10	0	9¼	0	6¾
12	10	29	4	63	84	154	0	0	8¼	0	8¾
13	9	29	5	62	80	155	6	0	9½	0	8½
14	10	29	6	66	80	155	4½	0	9½	0	7
15	10	29	5	62	80	155	9½	0	12¼	0	9¼
16	9	29	0	66	80	155	4	0	10½	0	7½
17	8	29	0	67		156	0	0	7	0	5
18	9	29	3	66		154	13	0	10¾	0	9¼
19	10	29	3	68	88	154	13	0	12	0	8
20	11	29	2	70	84	154	4	1	0¼	0	11¾
21	9	29	2	70	76	153	14	0	10	0	8
22	9	29	3	63	80	154	8	0	12¾	0	9¼
23	10	29	2	59	92	153	4	0	10½	0	10½
24											
25	8	29	3	59	80	153	6½	0	9½	0	8½
26	10	29	3	58	80	152	9½	0	9	0	11½
27	9	29	2	58	80	152	4	0	10¾	0	8¼
28	9	29	1	58	80	153	4½	0	8¾	0	7¼
29	9					153	12	0	12¼	0	10¾
30											
31											

DECEMBER.

Hour of the Night.	Barom.	Therm.	Pulses in Min. 1.	Night Weight.	Meat and Drink.	Day Urine.	Excrem.	Day Persp.	Winds.
12	29 3	60	76	155 10½	3 12½	1 5	0 6	1 00	NW
11	29 5	56	80	155 13					SW
12	29 2	58	88	157 11					SW
12	29 2	62	80	157 1					SW
1	29 3	59	96	158 8					SW
11	28 8	62	100	157 3					SW
11	29 1	64	96	157 5					NW
12	29 2	62	80	157 12					W
12	29 3	57	80	157 8					W
1	29 5	61	80	156 10					W
12	29 4	60	76	155 1					SW
12	29 5	61	96	156 8					S
1	29 6	63	80	156 5					N
12	29 7	64	80	156 15	4 12½	1 4¼	0 5½	1 8¼	S
1	29 1	63		156 6	3 12½	1 8¾	0 0	1 7¼	S
1	29 0	66	88	156 12					
11	29 2	66	84	156 1	3 0	1 6½	0 7	1 1½	E
11	29 4	66	88	156 1					E
12	29 3	68	80	156 0	4 7½	1 8½	0 7	1 5	E
12	29 2	70	80	155 0					E
11	29 3	66	80	155 14					SE
12	29 2	60	80	154 9					S
12	29 3	59	80	154 8½					S
12	29 4	58	100	153 14					S
11	29 3	57	72	153 7	3 14	1 7½	0 4	1 5	S
1	29 2	56	84	154 3½					S
11	29 0	56	88	155 3					SE
11	29 8	58	84	155 6					

Day

JANUARY.

Day of the Month.	Hour of the Morning.	Barom.		Therm.	Pulses in Min. 1.	Morning Weight.		Morning Urine.		Night Persp.	
1	9	29	0	59	84	154	0	0	11	0	11
2	9	29	0	61	80	154	1½	0	8	0	8½
3	9	29	1	59	80	154	7	0	9	0	9
4	9	29	2	62	80	154	15	0	8½	0	8½
5	9	29	3	59	80	154	7	0	13	0	10
6	9	29	4	52	84	154	2	0	13	0	9
7	9	29	3	55		154	5½	0	9¾	0	10¾
8	9	29	2	54	80	154	2	0	12	0	10
9	10	28	9	53	80	154	7	0	12	0	11
10											
11	9	28	6	61	84	154	1	0	13	0	8
12	8	28	9	66	80	154	3	0	11	0	8
13	10	29	2	68	76	153	10	0	13	0	9
14	9	29	2	59	84	153	7	0	13	0	8
15	9	29	1	66	84	153	1	0	8	0	7
16	9	29	2	63	80	153	14	0	12	0	8
17	10	29	3	61	80	154	1	0	9	0	8
18	9	29	1	61	80	153	13	0	9¾	0	8¼
19	9	28	9	61	80	154	0	0	14	0	9
20	9	29	1	64	80	153	2	0	11½	0	8½
21	10	29	0	59	84	153	3	0	11	0	8
22	9	28	6	61	92	152	6½	0	15¾	0	6¾
23	9	28	8	63	84	152	10	0	13	0	8
24	9	29	0	60		153	10	0	8	0	8
25											
26											
27	9	29	3	66	88	153	5	1	0	0	11
28	10	29	6	68	80	152	10	0	11¼	0	10¾
29	9	29	8	70		153	15	0	8½	0	8½
30	10	29	9	68	80	153	4½	0	11	0	9½
31	9	29	7	72	80	154	5	0	12	0	9

Hour

JANUARY.

Hour of the Night.	Barom.	Therm.	Pulses in Min. 1.	Night Weight.	Meat and Drink.	Day Urine.	Excrem.	Day Persp.	Winds.
12	29 0	60	84	155 2					N E
12	29 0	60	80	155 9					N E
12	29 2	58	80	156 0					N E
12	29 4	60	96	155 14	3 14½	1 7	0 4	1 4½	S
11			92	155 8					S
12	29 3	53	80	155 12½					S
11	29 3	53	94	155 8					S
12	29 1	52	104	155 14					S W
1	28 5	59	84	155 6					
11	28 8	64	100	155 6	3 12	1 3½	0 0	1 3½	E
12	29 2	66	84	155 0					N E
11	29 2	68	80	154 12					N E
1	29 1	69	84	154 0					S
11	29 1	64	96	155 2					S
1	29 3	64	80	155 12					S
12	29 2	60	80	154 15					S
11	29 0	60	84	155 7					E
11	28 9	66	92	154 6	3 9¼	1 5¼	0 4	1 10	N
12	29 1	60	80	154 6	3 12	1 8¼	0 0	0 15¾	S
1	28 6	60	92	153 13	4 11	1 12½	0 6	1 14½	S
12	28 7	61	100	153 15	4 00	1 5½	0 0	1 2	S
12	29 0	60	80	154 10					S
12	29 1	65	88	155 0	Full Moon.				N
12	29 4	68	88	154 0					
1	29 8	69		155 0					
11	29 9	69	88	154 9					
1	29 8	70	92	155 10					

FEBRUARY.

Day of the Month.	Hour of the Morning.	Barom.		Therm.	Pulses in Min 1.	Morning Weight.		Night Urine.		Night Persp.	
1											
2											
3	10	29	4	78	88	153	6	0	12	0	8
4	9	29	4	78	88	152	14	0	11	0	8
5	10	29	3	78	84	152	0	0	8¾	0	7¼
6											
7	8	29	5	75	76	154	15¼	0	12¾	0	7
8	9	29	3	77	80	155	8	0	14	0	8
9	8	29	3	80	80	155	2¼	1	00	0	8
10	9	29	5	78	88	154	4	1	00	0	8
11	9	29	8	75	84	154	8	0	11	0	9
12	9	30	0	71	80	153	12	0	10	0	7
13											
14											
15	10	29	5	65		154	6½	0	12	0	14
16	8	29	5	66		156	5¾	0	9¼	0	7
17	9	29	5	64	80	155	15½	0	11½	0	7
18	9	29	3	63	76	156	0¾	0	13¼	0	7
19	8	29	3	62	80	154	6¼	0	11¾	0	4
20	9	29	3	63	80	155	5½	1	1½	0	7
21	10	29	2	59	80	156	7	0	14	0	8
22	8	29	0	64	80	156	7	0	13	0	8
23	8	29	3	67	76	155	6	0	13	0	7
24	8	29	5	59	80	155	2½	0	10½	0	7
25	8	29	5	55	80	155	7	0	10	0	6
26	8	29	2	55	84	154	5	0	11	0	9
27	8	29	1	57	80	154	5½	0	12	0	8
28	8	29	1	56	84	154	11¼	0	12¾	0	8
29	9	29				154	3½	0	10½	0	9

FEBRUARY.

Hour of the Night.	Barom.	Therm.	Pulses in Min. 1.	Night Weight.	Meat and Drink.	Day Urine.	Excrem.	Day Persp.	Winds.
12	29 5	76		154 10					N
12	29 5	77	92	154 0					N
12	29 3	76	84	153 0	5 14	1 7	2 9	1 12	N
12	29 5	75	84	156 3					NW
12	29 3	74	80	156 14					NW
11	29 3	76	80	156 $10\frac{1}{4}$	5 1	1 $14\frac{1}{2}$	0 $4\frac{1}{4}$	1 $10\frac{1}{4}$	NW
1	29 5	78	96	155 12					NW
11	29 8	74	88	155 12					
12	30 0	71	80	154 13	3 2	1 $8\frac{1}{4}$	0 0	1 $4\frac{3}{4}$	S W
12	29 7	61		156 $0\frac{1}{2}$					
11	29 5	64	100	157 6					
12	29 5	64	92	157 2					
12	29 5	61	92	157 5					
1	29 4	61	88	155 6					W
12	29 3	60	68	156 14					W
1	29 3	59	96	157 13					S
11	29 1	59	84	157 12					S W
11	29 2	65	92	156 10					S W
12	29 5	61	84	156 4					S W
12	29 5	55	100	156 7					S W
11	29 4	53	88	155 9					S W
11	29 2	55	88	155 10	4 12	1 $10\frac{1}{4}$	0 $4\frac{1}{2}$	1 $8\frac{1}{4}$	S
11	29 2	54	94	156 0					S
11	29 0	54	100	155 7					S W
12	29 0	54	100	156 11					S W

MARCH.

Day of the Month.	Hour of the Morning.	Barom.		Therm.	Pulses in Min. 1.	Morning Weight.		Night Urine.		Night Persp.	
1	9	29	0	56	76	155	7	0	13	0	7
2											
3	8	29	1	56	80	155	10	0	15	0	7
4											
5											
6											
7	9	29	5	58	76	155	12	0	14½	0	10½
8	8	29	7	65	72	156	4	0	13	0	6
9	8	29	7	67	80	155	14	1	00	0	7
10	9	29	3	68	76	156	3	1	1¼	0	8¾
11	9	29	2	67	84	155	8¾	0	15¼	0	9
12	10	29	4	67	80	155	4	0	15	0	10
13	8	29	5	70	80	154	10	0	7	0	9
14	10	29	6	68	80	154	14	0	11	0	8
15	8	29	4	67	84	155	11	0	13¼	0	7¾
16	8	29	4	67	84	156	3½	0	13½	0	8
17	7	29	5	66	80	156	6	0	14	0	7
18	9	29	5	62		155	9½	0	11½	0	8
19	8	29	3	61	84	155	11½	0	11½	0	7
20	8	29	2	60	84	155	10¾	0	14¼	0	9
21	9	29	1	61		154	14¾	0	13¼	0	9
22	8	29	1	54	72	155	13	1	5¾	0	7¼
23	8	29	0	52	84	154	13	0	11	0	8
24											
25											
26	9	29	2	55	80	155	3½	0	12½	0	9
27	9	29	2	53	80	158	6½	0	14½	0	8
28	9	29	2	54	76	157	6	1	1	0	9
29	9	29	3	55	76	157	9	1	4¼	0	9¾
30	9	29	1	56	80	156	11½	1	1½	0	9
31	8	29	0	60	76	156	13	0	13	0	9

Hour

Hour of the Night.	Barom.	Therm.	Pulses in Min. 1.	Morning Weight.	Meat and Drink.	Day Urine.	Excrem.	Day Persp.	Winds.
11	29 3	53	88	157 0					
12	29 5	54	105	157 5					S
11	29 5	64	92	157 7	5 0	1 11¼	0 3¾	1 6	N E
12	30 0	64	84	157 5	5 14	3 5	0 0	1 8	N E
11	29 5	65	92	157 13	5 6½	2 3¼	0 0	1 4¼	S
11	29 3	66	84	157 1					N E
11	29 4	66	80	156 13	4 4	1 12	0 6	0 13¾	N E
12	29 5	68	84	155 10					N E
1	29 6	68	88	156 1					N E
11	29 5	66	100	157 0					N W
11	29 5	65	92	157 9					N W
11	29 5	65	92	157 11					S
12	29 5	63	92	156 13					S
12	29 3	62	92	156 14					E
12	29 2	60	84	157 2					E
11			96	156 5					E
12				157 10					S
12	29 2	49	80	156 0					S
12	29 2	52	94	156 9					N
1	29 2	52	110	159 12					E
12	29 2	53	88	159 0					S
11	29 3	53	84	159 7	5 8½	1 14	0 4	1 5½	S
11	29 2	55	100	158 6					S
11	29 3	53	96	158 3					N
12	29 1	60	104	158 6	5 9	2 6½	0 7	1 2½	N

APRIL.

Day of the Month.	Hour of the Morning.	Barom.		Therm.	Pulses in Min. 1.	Morning Weight.		Morning Urine.		Night Persp.	
1	9	29	1	60	80	157	0	0	14	0	8
2	9	29	0	59	76	156	11	0	14	0	8
3	9	29	0	59	76	155	2	0	15	0	8
4	8	29	3	58	74	155	12	1	1	0	7
5	9	29	5	54	80	155	15	0	15	0	9
6	8	29	5	53	76	156	4½	0	14½	0	7
7	8	29	6	52	76	157	4½	1	2½	0	10
8	8	29	6	50	76	156	2½	1	2½	0	7
9											
10	7	29	5	50	80	155	10	0	11	0	10
11	8	29	6	51	84	156	8	1	6	0	9
12	8	29	6	48	76	157	5	1	3	0	10
13	8	29	6	47	76	156	12¼	0	15¾	0	8
14	10	29	7	48	80	155	6	1	1½	0	10½
15	8	29	8	53		154	10	0	12½	0	10½
16	8	29	7	54	80	154	3	0	12	0	8
17	8	29	7	55	76	154	11	0	13	0	7
18	9	29	8	54	80	154	5	0	14	0	8
19	8	29	8	55	80	154	12¼	1	1¾	0	8
20	9	29	9	57	76	154	0	0	11	0	9
21	9	29	8	56	88	153	9	0	10	0	8
22	8	29	9	56	80	154	2	0	10	0	8
23	8	29	9	59	84	154	7½	0	1½	0	7
24											
25	9	29	6	62	84	153	5	0	11	1	9

Hour

APRIL.

Hour of the Night.	Barom.	Therm.	Pulses in Min. 1.	Night Weight.	Meat and Drink.	Day Urine.	Excrem.	Day Persp.	Winds.
12	29 0	58	96	158 1	4 14	2 $3\frac{1}{2}$	0 0	1 $10\frac{1}{2}$	E
11	29 0	58	84	156 9	3 2	1 $10\frac{1}{4}$	0 6	1 $3\frac{3}{4}$	N E
12	29 3	58	92	157 4					N
11	29 5	54	92	157 7					S E
11	29 5	51	100	157 10					S W
11	29 6	50	84	159 1					S W
12	29 6	49	76	157 12					S
11	29 4	50	100	156 15					N
12	29 6	49	96	158 7					S
11	29 7	45	92	159 2					S
11	29 6	45	88	158 4	5 2	2 $3\frac{1}{2}$	0 9	1 7	E
11	29 7	45	84	157 2					E
11	29 8	50	96	156 1	3 11	1 $5\frac{3}{4}$	0 $7\frac{1}{2}$	1 $2\frac{3}{4}$	E
11	29 9	51	84	155 7					N
12	29 8	52	100	155 15					N
12	29 8	54	80	155 11					N
11	29 9	53	96	156 6					E
12	29 8	57	92	155 4					N
12	29 9	56	92	154 11					N E
12	29 9	55	104	155 4					N E
12	29 9	58	112	156 4					N E
									N
12	29 7	60	84	154 9					N
11	29 7	60	80	155 0					N

Day

MAY.

Day of the Month.	Hour of the Morning	Barom.		Therm.	Pulses in Min. 1.	Morning Weight.		Night Urine.		Night Persp.	
1											
2											
3											
4											
5											
6											
7											
8											
9	9	29	5	50		155	3	1	00	0	10
10	8	29	6	48	84	154	10	1	2	0	11
11	9	29	5	46	80	154	10½	1	14½	0	9
12	9	29	6	46	84	155	7	1	00	0	11
13											
14											
15	9	29	7	44	76	154	6	1	00	0	11
16	7	29	5	46	84	155	3	1	10	0	8
17	8	29	5	45	76	155	11	1	3	0	11
18	7					155	8	1	4	0	8
19											
20	9	29	6	44	80	156	4½	1	0½	0	10
21	8	29	7	44	76	156	3	0	14	0	10
22	8	29	6	42	72	157	3	1	3	0	10
23	8	29	5	41	80	156	8	0	10	0	10
24	8	29	6	44	80	157	1½	0	13½	0	10
25	7	29	6	44	80	155	14	0	13	0	10
26											
27											
28											
29	9	29	8	45	88	157	12	0	11	0	11
30	9	29	9	41	84	156	9	0	9½	0	8½
31	6	29	7	41	92	157	3	0	10	0	8

MAY.

Hour of the Night.	Barom.	Therm.	Pulses in Min. 1.	Night Weight.		Meat and Drink.	Day Urine.	Excrem.	Day Persp.	Winds.
11	29 5	49	112	156	13					
12	29 6	47		156	7					
12	29 5	44	84	156	2					S
12	29 5	43	108	157	2					S
12	29 5	45	96	156	10					S
11	29 9	41	100	156	1					W
12	29 4	46	96	157	5					
10	29 5	44	84	157	9					S W
12	29 5	43	96	157	4					S W
11	29 5	43	88	157	15					
11	29 8	42	100	157	11					N
11	29 8	40	76	159	0					S
11	29 6	40	88	157	12					S
11	29 6	42	84	158	9	4 14	1 1	0 0	1 12	N
11	29 7	41	88	157	5					N
12	29 8	42	92	157	9					E
11	29 8	42	88	159	2					
12	29 9	40	92	157	11					E
12	29 8	37	100	158	5	4 15	1 6	0 5	1 8	N E
11	29 8	35	84	159	14	6 1	1 10	0 0	1 12	S W

Day

JUNE.

Day of the Month.	Hour of the Morning.	Barom.	Therm.	Pulses in Min. 1.	Morning Weight.	Night Urine.	Night Persp.
1	7	29 6	40	76	158 2½	0 15½	0 12
2	8	29 6	37	84	157 12½	0 11½	0 14
3	9	29 6	39	80	158 2	0 15	0 10
4	9	29 9	40	80	158 12	1 1	0 12
5	7	29 8	39	80	157 15	0 13	0 8
6	9	29 7	37		157 10	0 9	0 10
7	8	29 5	43	80	157 15	0 11	0 10
8	8	29 4	43	80	158 8	0 14	0 10
9	9	29 5	44	72	159 6	0 13	0 8
10	7	29 6	45	80	158 12½	0 13½	0 8
11	10	29 6	46	84	158 1	1 00	0 10
12	8	29 5	47	84	157 7½	0 11½	0 8
13	8	29 5	45	84	157 9	0 10	0 8
14	8	29 5	44	72	158 4	1 0	0 10
15	8	29 6	45	80	158 15	0 10	0 7
16	7	29 6	44	76	159 5	0 10	0 8
17	7	29 5	45	76	159 2	0 15	0 9
18	8	29 4	46	88	158 7½	0 9½	0 9
19	7	29 4	43	84	159 12	0 8	0 7
20	9			76	159 3	1 6½	0 9½
21	6	29 6	44	68	160 2	0 12½	0 8
22	8	29 5	44	84	159 9	0 11	0 9
23	8	29 6	46	80	159 14	0 10	0 10
24	9	29 5	41	92	160 1½	1 0½	0 10
25	10	29 5	40	72	159 4	1 1	0 11
26	7	29 4	43	80	158 8	0 7	0 8
27	8	29 5	43	80	159 2½	1 4½	0 10
28	8	29 9	40	80	159 12½	0 10½	0 10
29	9	29 9	40	84	158 9	0 7	0 8

Hour

JUNE.

Hour of the Night.	Barom.		Therm.	Pulses in Min. 1.	Night Weight.		Meat and Drink.		Day Urine.		Excrem.		Day Perſp.		Winds.
12	29	7	36	108	159	6									
12	29	6	37	100	159	11									S W
11	29	8	37	88	160	9									N
12	30		36	92	159	4									N
12	29	9	34	88	158	13									N
11	29	6	39	100	159	4	5	6	1	3 ½	0	5	2	3 ½	N
11	29	4	41	92	160	0									W
12	29	4	44	72	160	11	5	5 ½	1	12 ½	0	0	1	6	N
12	29	5	44	76	160	2									N
11	29	6	45	80	159	11									N
12	29	6	44	100	158	11									N
12	29	6	43	104	158	11									N
11	29	5	44	88	159	14	6	1	1	4	0	2 2	2	5 ½	N
12	29	6	43	88	160	0									N
12	29	7	42	100	160	7	5	4	1	6 ½	0	4	2	1 ½	N
11	29	5	43	76	160	10									N
11	29	5	45	100	159	10	4	11	2	1 ½	0	6	1	11 ½	N
12	29	4	42	92	160	11									N
12	29	5	44	84	161	3									E
11	29	7	14	84	161	6	5	2	1	4 ½	0	0	1	10 ½	N
11	29	5	43	92	160	13									N
11	29	7	42	84	161	2									N
1	29	6	42	104	161	12									N
11	29	5	40	88	161	0	4	8	1	9	0	10 ½	1	6	S W
12	29	5	40	80	159	7									W
12	29	5	41	76	161	1									N W
12	29	9	37	100	161	1									N
2	29	9	37	100	159	8									

Table I. of Obſervations.

	Day of the Month.	Hour of the Morning.	Barom.		Therm.	Pulſes in Min. 1.	Morning Weight.		Morn. Urine.		Night Perſp.	
Aug.	3		29	9	21							
	4											
	5	6	29	6	25	80	160	7	0	8	0	6
	6	7	29	5	21	80	160	4	0	11	0	11
	7	9	29	4	28	72	160	6	1	00	0	11
	8	Perſpired in 3 hours after dinner ℥vi.										
	15											
	16	8					160	10	0	11	0	8
	17	8	29	5	31	80	160	9	0	11	0	13
Dec.	30											
	31	10	29	3	85	80	160	14½	0	13	0	6
Jan.	1	10	29	4	86	84	160	13½	0	15	0	5
	2	10	29	4	84		160	12½	0	11	0	6
	3	10	29	1	91	80	160	11	0	13½	0	6
	4	10	29	4	83	80	160	2	0	13½	0	5½
	13		29	2	83							
	14		29	2	73							
Feb.	12											
	13	9	29	5	84	82	159		1	6	0	6
	14	10	29	6	81	84	158	13	0	12	0	7
	16	10	29	3	87	88	159	4				
	17	9	29	1	87	84	158	8	0	8	0	6
	19											
	20	9	29	4	74	92	158	12	0	9	0	4
	21	8	29	5	72	72	159	6	0	10	0	5
	22											
	23	7	29	7	80	65	160	11	0	10	0	4

Hour

Hour of the Night.	Barom.		Therm.	Pulses in Min. 1.	Night Weight.		Meat and Drink.		Day Urine.		Excrem.		Day Persp.		Winds.
11	29	7	21	96	161	5									
11	29	6	18	92	161	10									
11	29	4	25	92	162	1	6	0½	2	12½	0	0	1	7	
Perspiration of 2 hours after dinner ℥iiss.															
11	29	8	29	92	161	13									
11	29	7	30	76	162	1									
															E
12	29	6	81	80	162	1½									N E
11	29	1	92	84	162	1½	3	15	1	5½	0	0	1	6½	N E
12	29	4	86	80	161	3½	3	10	1	1	0	6	1	13	
															N
11	29	3	85		161	14½	4	2	1	1	0	0	1	15	E
12	29	4	83	84	161	5	3	11	1	5½	0	3	1	8	N
12	29	5	82	82	160	12									
11	29	6	81	90	160		4	9	1	5½	0	9	1	10½	NW
11	29	3	84	96	158	14	2	15	1	5½	0	0	1	15½	E
12	29	4	75		159	9									
11	29	5	72	88	160	5	4	10	1	3	0	7	1	7	E
11	29	6	69	100	161	9	5	7	1	8	0	0	1	12	S
12	29	7	64	92	161	9									S

TABLE II.

	Day of the Month.	Hour of the Morning.	Barom.		Therm.	Morning Weight.		Morning Urine.		Night Persp.	
March	20										
	21	9	29	1	64	161	15	0	11	0	7
	22	8	29	1	67	160	10½	0	14½	0	7
	26										
	27	9	29	4	64	161	7½	1	3½	0	5
	28	8	29	2	62	161	9	1	0	0	5
	29	9	29	4	61	161	15	0	11	0	6
	30	7				161	0	0	10	0	5
April	3										
	4	9	29	2	50	158	12	0	13	0	8
	5	9	29	4	52	158	12	0	11	0	10
	6										
	7	8	29	7	49	160	5	0	12	0	9
	9										
	10	8	30	1	43	159	6	0	8	0	10
	18										
	19	7				159	2	0	7	0	8
	26										
	27	8	29	8	50	158	7	0	7	0	8
May	18										
	19	9	29	6	48	158	11½	0	13½	0	9
	20	8	29	6	47	156	13	0	10	0	8
	21	8	29	5	46	157	6	0	13	0	9
	22										
	29										
	30	9	29	5	44	158	3	1	0	0	9
June	6										
	7	9	29	8	40	156	1½	0	8½	0	9
	8	9		8	41	158	6½	0	10½	0	9
	9	7	29	8	42	158	1	0	10	0	6

Hour

TABLE II.

Hour of the Night.	Barom.	Therm.	Night Weight.	Meat and Drink.	Day Urine.	Excrem.	Day Persp.	Winds.
10	29 2	60	162 1					
10	29 1	65	162 0					
12	29 7	61	163 2					
10	29 4	62	162 14	5 0	1 12	0 3½	1 10	
11	29 4	59	163 0					
11	29 5	60	161 15	3 11	1 8	0 6	1 13	
11	29 1	50	160 1					
11	29 2	49	160 1	4 2	1 0½	0 5	1 7½	S
11	29 7	46	161 10					
12	30 1	43	160 8					
11	29 4	50	160 1					
12	29 8	54	159 6					
12	29 7	47	160 0					
11	29 6	46	157 15	2 9	1 11	0 4	1 6½	
11	29 6	44	158 12	4 14	1 9	0 0	1 6	N
12	29 4	44	159 12					
11	29 8	39	157 3					
12	29 7	43	159 10					E
11	29 8	40	159 1	3 10	1 6½	0 5	1 4	

Day

TABLE III.

	Day of the Month.	Hour of the Morning	Barom.	Therm.	Morning Weight.	Morning Urine.	Night Persp.	Pulses in Min. 1.
July 1709.	23							
	24	8	29 9	32	158 9½	0 6½	0 8	
	25	8	29 7	36	158 2	0 7	0 9	
	26	9	30 0	35	158 0½	0 11½	0 8	
Sept. 1711.	21							
	22	8	29 9	45	169 11¾	0 14¼	0 11	
	23							
	24	Purged with Pills in the Morning.						
	25	8	30 1	46	167 8½	0 9½	0 11	68
	26	9	30 0	46	171 1	0 9½	0 11	72
	27	9	29 9	43	169 3½	0 10½	0 7	80
	28	8	30 1	44	170 7	0 11	0 10	80
June 1712.	12							
	13	8	30 0	23	168 13¾	0 7	0 11¼	80
June 1713.	6							
	7	8	30 1	36	170 15¼	0 10¼	0 10	72
	8	9	30 2	35	171 11½	0 11½	0 8	76
	9	8	30 2	36	171 7	0 12½	0 8	80
	10	9	30 2	34	169 7½	0 8½	0 8	68
	11	6	30 0	34	171 7½	0 7	0 6½	
	12	9	30 0	36	169 3¼	0 7½	0 7	72
	13							
	14	9	30 2	33	170 13	1 0	0 9	76
	15							
	16	8	30 2	30	169 9½	0 7½	0 8	76
	21							
	22	8	30 0	28	170 13	0 10	0 10	92
July	6							
	7	8	30 0	39	170 15	0 10	0 9	76
March	10							
	11	8	30 2	59	177 14½	0 11½	0 9	80
	12	9	29 9	58	177 6	10 0	0 9	

Hour

TABLE III.

Hour of the Night.	Barom.	Therm.	Night Weight.	Meat and Drink.	Day Urine.	Excrem.	Day Persp.	Winds.	Pulses in Min. 1. in Even.
12	30 0	29	159 8						
11	29 8	32	159 2	3 7	0 13	0 9	1 8 ½	S W	
12	29 9	35	159 4	4 2 ½	0 15 ½	0 5	1 12	W	80
11	30 0	33	160 4	4 12	1 3 ½	0 0	1 5		84
11	29 9	43	170 5						80
11	29 9	40	168 13						100
12	30 1	45	172 5						92
12	29 9	40	170 5	5 3	0 13 ¼	3 0 ½	2 1 ¼		80
11	30 0	42	171 12						84
11	30 1	18	170						92
12	30 1	36	172 3 ½					E	80
12	30 2	34	172 14 ½					E	92
12	30 3	35	172 11 ½					E	72
12	30 2	33	170 8					S E	80
12	30 2	33	172 5					S	92
12	29 9	34	170 2						76
11	30 2	30	172 6						80
12	30 1	29	170 9						72
12	30 0	25	172 1						94
12	29 9	37	172 2						80
11	30 2	57	179 3					E	84
12	30 0	56	178 9					E	88

Day

TABLE IV.

	Day of the Month.	Hour of the Morning.	Barom.		Therm.	Night Weight.		Night Urine.		Night Persp.		Pulses in Min. I.
June 1714.	13					lb.	℥.					
	14	7	30	1	29	177	11	0	9	0	11	80
	22											
	23	8	30	1	21	178	0	0	9	0	13	80
	24	7	30	2	21	178	2	0	7	0	11	80
	25	8	30	3	18	178	13	0	9	0	13	84
Mar. 1715.	27											
	28	7	29	7	55	172	5½	0	7½	0	9	76
	29	7	30	0	55	172	7½	0	9½	0	10	80
	30	7	30	0	51	173	3	0	8	0	8	80
Aug. 1717.	1											
	2	8	30	2	30	174	4	0	7	0	9	80
	4											
	5	8	30	3	29	174	13	0	13	0	12	80
	9											
	10	8	30	3	36	174	8	0	10	0	10	80
	13											
	14	8	30	1	39	174	4			0	8	
Nov.												
	14											
	15	8	29	7	60	174	13	0	8	0	8	70
Dec. 1717.	20											
	21	7	30	2	55	142	3	1	15	1	4	
	25											
	26	9	29	4	77	141	13	0	15	1	14	
	27	8	29	4	77	137	14	0	6	0	6	80
	28	9	29	6	80	139	02	0	12			

Hour

TABLE IV.

Hour of the Night.	Barom.		Therm.	Night Weight.		Meat and Drink.		Day Urine.		Excrem.		Day Persp.		Pulses in min. 1.
11	30	1	27	178	15									94
12	30	1	19	179	6									100
11	30	2	17	179	4									100
12	30	3	13	180	3									100
11	29	5	54	173	6									92
11	29	9	51	173	11									96
11	30	0	48	174	3									92
12	30	1	29	175	4									92
10	30	2	26	176	6									92
11	30	2	35	175	12									84
11	30	1	37	174	12									
12	29	9	60	175	13									92
11	30	2		145	4									76
11	29	5	77	144	10									84
10	29	4	75	137	2	00	0	0	12	00	00	3	15	
2	29	7	80	140	14	8	06	2	8	00	11	2	3	

TABLE V.

	Day of the Month.	Hour of the Morning.	Barom.		Therm.	Pulses in Min. 1.	Morning Weight.		Morning Urine.		Night Persp.
May	14	7									
	15	8	30		29	82	158	6	0	6	20
	16	8	29	7	34	72	157	13	0	8	23
	17	9	29	7	37	84	156	7	0	8	11
	18	9	29	9	39	80	156	5	0	7	12
	19	8	29	7	41	80	157	9	0	8	14
	20	8	29	8	39	84	158	1	0	7	13
	21	7	29	9	37	92	158	8	0	7	11
	22	8	29	9	34	92	157	00	0	$6\frac{1}{3}$	$10\frac{2}{3}$
	23	8	30	2	37	96	156	12	0	$6\frac{2}{3}$	$09\frac{1}{3}$
	24	8	30	4	37	84	155	15	0	5	11
	25	8	30	4	34	76	157	04	0	7	18
	26	8	30	3	34	92	156	11	0	7	21
	27	7	30	3	31	84	157	13	0	$6\frac{1}{2}$	$16\frac{1}{2}$
	28	7	30	1	27	80	157	2	0	$6\frac{1}{3}$	$19\frac{2}{3}$
	29	8	29	9	27	116	154	00	0	$4\frac{1}{3}$	$10\frac{2}{3}$
	30	8	29		29	92	155	07	0	7	12
	31	7	30	1	31	84	156	10	0	5	11
June	1	7	30	1	31	80	157	1	0	7	16
	2	8	29	9	28	100	155	11	0	$6\frac{1}{2}$	$20\frac{1}{2}$
	6										
	7	9	29	9	32	88	157	09	0	9	13
	8	8	29	9	35	80	158	05	0	8	16
	9	8	29	8	33	92	157	9	0	8	16
	10	8	29	9	34	84	157	12	0	$7\frac{1}{2}$	$18\frac{1}{2}$
	11	9	29	9	34	80	157	10	0	6	17
	12	8	29	9	34	80	158	15	0	8	17
	13	9	30	1	34	88	157	8	0	12	16
	14	8	30	2	34	80	156	13	0	$7\frac{2}{3}$	$13\frac{1}{3}$
	15	8	30	1	33	84	158	12	0	$8\frac{1}{3}$	$16\frac{2}{3}$
	16	8	30		33	84	159	4	0	$7\frac{1}{2}$	17_{2}
	17	9	29	8	34	84	158	2	0	$9\frac{1}{3}$	$11\frac{2}{3}$
	18	8	29	8	36	76	157	3	0	13	16

TABLE V.

Hour of the Night.	Barom.		Therm.	Pulses in Min. 1.	Night Weight.		Meat and Drink.		Day Urine.		Excrem.		Day Persp.	
10	29	9	24	85	160									
10	29	8	29	84	159	12								
2	29	6	31	86	157	10								
12	29	9	34	84	157	8								
11	29	7	39	112	158	15								
11	29	7	41	92	159	12	℔	℥					℔	℥
12	29	9	37	116	159	10	5	06	27	℥	5	℥	1	10
12	29	8	34	132	158	10								
11	30	1	35	104	157	12								
11	30	3	35	100	156	15								
12	30	4	34	120	158	13								
15	30	4	33	120	158	07								
10	30	3	29	100	159	04								
10	30	2	25	96	158	12			℥		℥		℔	℥
10	29	9	25	104	154	15	00	00	10		2		1	7
12	29	8	27	120	156	10								
12	30	1	30	120	157	10								
11	30	1	31	84	158	8								
11	29	9	27	112	157	6								
11	30		31	104	158	15								
11	29	8	34	096	159	13								
10	29	9	32	96	159	01								
12	29	9	32	164	159	6								
11	29	9	34	100	159	1								
12	29	9	34	104	160	8								
11	30		32	116	159	4	℔	℥	℔		℔		℔	
11	30	2	32	84	158	2	3	04	1	02	0	05	1	7
12	30	1	33	108	168	5								
11	30		31	96	160	13								
11	30	1	34	80	159	07								
10	29	9	32	92	159		℔						℔	℥
11	29	9	32	88	156	1	3	06	1	08½	0	04	2	11½

TABLE VI.

This TABLE ſhews the Perſpiration and Urine evacuated in one Hour both by Night and Day in each Month.

PERSPIRATION.			URINE.	
Night.	Day.	Month.	Night.	Day.
℥	℥		℥	℥
0 961	1 477	January	1 209	1 974
850	1 677	February	1 362	1 722
892	1 348	March	1 589	2 382
951	1 543	April	1 666	2 087
1 114	1 872	May	1 758	1 382
1 115	2	June	1 534	1 609
1 329	1 582	July	1 498	1 545
1 093	1 526	Auguſt	1 147	1 439
1 104	1 561	September	1 5	1 333
950	1 355	October	1 296	1 822
875	1 515	November	1 431	1 835
934	1 348	December	1 202	1 581
12 168	18 804		17 192	20 711

Obſervations

Obſervations of one entire Year, accommodated to each Month, in the Order in which they are already ſet down.

JULY.

Day

3. FULL Moon.
10. A larger Supper than uſual.
13. Moon *in Perigæo.*
14. Drank a pint of Mead going to reſt.
18. New Moon.
23. No Supper, drank more Wine than uſual, but only to chearfulneſs, which I always mean by this Expreſſion.
24. A Sweat broke out after Morning Sleep.
26. The Body was moiſt with Sweat upon waking. Moon *in Apogæo.*
29. No Supper, and no Drink after Dinner.

AUGUST.

Day

1. NO Supper.
2. No Supper. Full Moon.
3. Took a Purge of Jalap ℈ii.
4. No Supper.
5. Purged with *Elixir ſalutis* ℥iii.

Day

8. Tired with much riding.

9. Moon *in Perigæo.*

12. Tired with riding.

14. Supped on Water-gruel.

16. Supped on Water-gruel. New Moon.

18. Rode much. Was rubbed all over with a Bruſh at going to reſt.

20. Tired with much riding.

22. Rubbed with a Bruſh to redneſs at lying down in Bed.

23. Moon *in Apogæo.*

26. This diminution of weight ſeems to be owing to much riding.

27. In the Space of twenty-four Hours out of five pound of Meat and Drink the Body retains about two, that it may return to its uſual weight, and reſtore what is waſted with Labour.

30. Full Moon.

SEPTEMBER.

Day

1. RODE much.

2. After weighing at Night, ℔ 1. ℥viii. was perſpired by Bathing in warm Water, drank ℥vii. and ʒii. of Mead, whence the Night Perſpiration was ℥13 ¼.

3. Purged with *ſal mirabile Glauberi.*

5. Slept ill in the Night.

6. Drank more than uſual. Moon *in Perigæo.*

10. Perſpired in ſix Hours after Dinner ℥ 10 ½.

Day

11. Perspired in three Hours before Dinner ℥ $4\frac{1}{2}$.
12. An unquiet Night.
14. New Moon. Perspired in five Hours riding after Dinner, the Wind being high, ℥ $13\frac{1}{2}$. No Supper.
17. No Supper.
19. Perspired in $2\frac{1}{2}$. Hours after Dinner ℥ 4.
20. Perspired in two Hours after Dinner ℥ $3\frac{3}{4}$, and in the two following Hours, in which more Motion was used, ℥ $4\frac{1}{4}$. Moon *in Apogæo.*
21. Perspired between Nine in the Morning and Noon ℥ $5\frac{3}{4}$; and in two Hours by the Fire ℥ $4\frac{1}{4}$.
22. Between Eight in the Morning and Noon the Perspiration was $3\frac{3}{4}$ Ounces.
23. Perspired in four Hours and a half riding before Dinner ℥ $9\frac{1}{2}$.
24. Perspired in three Hours before Dinner six Ounces. Supped on Oisters.
25. Perspired in $2\frac{1}{2}$ Hours before Dinner 5 Ounces.
26. Perspired in $3\frac{1}{2}$ Hours before Dinner $9\frac{1}{2}$ Ounces. Supped on Oisters.
27. Supped on Mushrooms.
30. Full Moon.

OCTOBER.

Day

3. MOON *in Perigæo.*
6. Supped on buttered Wheat.

7. Supped on Oisters. Layed another Blanket on the Bed.
9. No Supper.
10. Perspired in four Hours before Dinner eleven Ounces. Supped on Oisters.
14. New Moon.
16. Supped on Oisters.
17. Drank a pint of Bath-Waters in the Morning. Perspired in two Hours before Dinner four Ounces. Moon *in Apogæo.*
18. Perspired in $3\frac{1}{2}$ Hours before Dinner, with riding, $5\frac{1}{2}$ Ounces; Riding also after Dinner the Perspiration was $9\frac{1}{2}$ Ounces.
21. Sweated in Bed.
22. Sweated in Bed.
24. Perspired in three Hours both before and after Dinner three Ounces and a half.
29. Full Moon.
31. Moon *in Perigæo.*

NOVEMBER.

Day
6. PErspired in three Hours after Dinner three Ounces.
8. Drank more than usual.
9. Perspired in two Hours before Dinner two Ounces.
11. Drank a Pound and eleven Ounces of Bath-Water.
12. Drank 14 Ounces of the same Water.
13. New Moon. No Supper.
14. Supped on Oisters. Moon *in Apogæo.*
16. Drank more than usual.
18. Sweated in Bed.

19. No

Day
19. No Supper.
20. Drank a pint of Punch.
21. Drank the ſame Quantity of the ſame Liquor.
24. No Supper.
27. Moon *in Perigæo.*
28. Full Moon.

DECEMBER.

Day
3. DRANK Punch in the Evening.
5. Drank the ſame Liquor again.
11. No Supper. Moon *in Apogæo.*
13. New Moon.
19. Drank ſtrong Mead in the Evening.
25. Drank Mead again. Moon *in Perigæo.*
27. Full Moon.

JANUARY.

Day
1. NO Supper
8. Moon *in Apogæo.*
11. New Moon
13. No Supper.
18. Drank a pint of Bohea-Tea at going to reſt.
20. A Cough from catching cold with ſhaving the Head.
21. Drank a pint and eleven Ounces of Green-Tea in the Morning, a pint and eleven Ounces of Punch in the Evening.

22. Moon

22. Moon *in Perigæo.*
26. Full Moon. Drank a pint and a half of Punch, made with Green-Tea in the Evening.

FEBRUARY.

Day

4. PURGED with *Sal Catharticum amarum.* Moon *in Apogæo.*
9. Drank more Wine than usual.
10. New Moon.
15. No procatartic Cause appears of so great Perspiration in the Night.
18. Moon *in Perigæo.*
19. Nor does any Cause appear of this Diminution.
24. Full Moon.

MARCH.

Day

3. MOON *in Apogæo.*
8. Drank a Pound and seven Ounces of Bath-Water, and twelve Ounces of Tea.
9. Drank fifteen Ounces of Bath-Water, and twelve Ounces of Tea.
10. Drank the same Quantity of Bath-Water.
11. Drank the same Quantity of Bath-Water and Tea. New Moon.
12. Nothing Eat or Drank at Supper time.
17. Moon *in Perigæo.*

21. Drank

21. Drank in the Evening. Hence that Quantity of Urine in the Morning, but the Perspiration is a little altered.
22. No Supper.
25. Full Moon.
30. Moon *in Apogæa.*

APRIL.

Day
7. NEITHER Eat nor Drank at Supper time.
9. New Moon.
13. Moon *in Perigæo.*
20. No Supper.
23. Full Moon.
27. Moon *in Apogæo.*

MAY.

Day
8. NEW Moon.
11. Moon *in Perigæo.*
23. Full Moon.
24. Neither Eat nor Drank at Supper time.
25. Moon *in Apogæo.*

JUNE.

Day
7. MOON *in Perigæo.*
13. Drank almost four Pound. Rainy Weather.

16. Neither

16. Neither Eat nor Drank at Supper time.
19. Drank Tea at going to Bed.
21. Moon *in Apogæo.*
22. Full Moon.
25. A ſpare Supper.
26. Drank in the Evening.

The

The Obſervations of various Years.

TABLE. I.

AUG. Day 3. PErſpired in four Hours after Dinner one Pound, at which Time there were 92 Pulſes in a Minute.

4. Slept naked.

5. Perſpired in three Hours before Dinner eight Ounces.

6. A rainy Day. Drank two Pound of Chalybeate Waters in the Morning.

15. Perſpired in three Hours after Dinner nine Ounces.

DECEMBER. Day 3. Froſt and Snow.

JANUARY. Sat whole Days by the Fire, whence the Days Perſpiration was greater, and the Night leſs then in the *January* of the preceeding Year; the Night Perſpiration of one Hour is ℥0 54. the Day ℥1 97, and the Sum of both is to the Sum of both in the preceding Year, as 2. 438. to 2. 51; and ſo the

heat of the Fire in the coldeſt Weather cauſed Perſpiration.

13. Perſpired after Dinner five Ounces in three Hours.

14. Perſpired in two Hours before Dinner five Ounces, and in two Hours after Dinner four Ounces. A Thaw.

FEBR. Day 13. A very hard Froſt: Caught cold whence a Pain in the Tonſils.

15. Slept bare-headed in the Night, whence a grievous Cough was added to the Pain of the Tonſils.

16. Perſpired in five Hours after Dinner ten Ounces, after Supper perſpired by the Fire-ſide plentifully. A Thaw again.

22. From ſix in the Morning to one in the Afternoon perſpired with riding one Pound.

Here again, tho' the Night and Day Perſpiration differs from the Perſpiration of the *February* of the preceding Year, yet the Sum of both is equal.

Here the Night Perſpiration of one Hour is ℥0. 58. the Day 1. 94.

TABLE II.

MARCH, Day 28. My Cloaths being changed for thinner, I added a Flannel Waſtcoat next my Skin, that the warmth of my Cloaths might continue equal.

MAY, Day 20. I took off the Flannel.

JUNE, Day 6. Took a Purge.

TABLE

TABLE III.

SEPTEMBER. Day 26. Drank three Pound.

JUNE, Day 7. Supped late and plentifully.

9. No Supper.

11. No Supper.

TABLE IV.

JUNE, Day 24. Between ten in the Morning and Noon, when the Thermometer was at 15. the Perſpiration was ſix Ounces.

25. The Liquor in the Thermometer being up at 13. the Perſpiration of two Hours was ſeven Ounces.

AUG. Day 5. Going in a Coach the Perſpiration of three Hours was ſix Ounces, the Liquor of the Thermometer being up at 30.

DECEMB. Day 25. Studied in a Chamber, in which the Air being heated by a Fire raiſed the Thermometer to 35.

26. Walked ſix Miles from the Town.

27. This Night eighteen Ounces of moiſture was drawn from the Air whilſt aſleep.

TABLE V.

Containing Observations made by a young Man of 23 Years.

MAY, Day 14. No Meat or Drink was taken this Night.

15. 17. These Nights also he abstained from Eating and Drinking.

18. Eat a larger Supper than usual.

21. The Pulse was quickened with walking, and a Sweat broke out all over his Body.

23. No Supper.

24. No Supper.

25. Tired with much walking, and the Pulse accelerated.

27. A restless Night.

29. In sleeping from six to eight in the Morning he perspired three Ounces, the Pulse being accelerated with fasting Yesterday far exceeded the usual number.

30. The Pulse accelerated by walking.

JUNE Day 1. The Pulse accelerated by walking.

6. Being tired with a long Journey, he had a great Thirst which could not be quenched without frequent Drinking.

12. The Pulse being accelerated by riding, his Thirst was quenched by drinking more than usual; hence he made a great Quantity of Urine in the Night.

14. This Night he took no Sustenance; but the next he both eat and drank not a little.

STATICAL

STATICAL

APHORISMS.

APH. I.

SINCE all that a Man eats does not go into Blood and Juices; Nature has provided certain Outlets for the Evacuation of what is Superfluous and Excrementitious.

APH. II.

The moſt conſiderable Outlets, are the Anus, Kidneys, and Pores of the Skin; and the Quantities paſſing through theſe every Day, may be known by Statical Experiments.

APH. III.

Since very many Diſeaſes have their Riſe from what is taken in or ejected, the firſt Seeds of them may be diſcovered by weighing, and the Increaſes of them by a failure of the natural Functions.

APH. IV.

Five Ounces is commonly ejected in one Day by Stool.

APH. V.

Two Pound and almost six Ounces of Urine is discharged in one Day, or twenty four Hours.

APH. VI.

More than one and thirty Ounces is expended in one Day by Perspiration.

APH. VII.

All these are varied according to the Differences of Constitutions, Age, Meat and Drink, Sleep and Waking, Exercise and Rest, and the Seasons of the Year.

Explanation.] "The Quantity here com-
" puted, falls much short of *Sanctorius*'s Cal-
" culation, which [*Aph.* VI. *Sect.* I.] he
" makes $\frac{5}{8}$ of what is taken in by Meat and
" Drink, and in the XXI. *Aphorism* of the
" same *Section* he assigns the Quantity to be
" fifty Ounces. But this will not appear
" difficult to those who consider the Diffe-
" rence of Climate; for where he made *his*
" Trials was vastly warmer than where
" Dr *Keill* made *his*; and therefore would
" a great deal more, for that very Reason,
" be wasted by the Surface of the Body in
" insensible Steam. That the Variations of
" the Quantities also perspired arise from the
" Causes here assigned, exactly agrees with
" the VII. *Aphorism* of *Sanctorius*, *Sect.* I."

APH.

A P H. VIII.

How much foever the Proportions of Evacuation may be altered by feveral Caufes, yet in a moft healthful State, the Quantity ejected, is equal to the Quantity taken in.

Explanation.] "This agrees with the IX. " and X. of *Sanctorius*, *Sect.* I. under which " the Reafons for it may be feen."

A P H. IX.

More Urine is made in the Day-Time than in the Night.

Explanat.] " Becaufe the Warmth of the " Bed draws more out by the Pores of " the Skin, and leaves lefs to feparate by " the Kidneys into the Bladder. By Ex- " ercife alfo, and in the Day-Time, a Per- " fon is more frequently under fuch Con- " tractions and Preffures of the Fibres, as " very much conduces to draw out what is " collected in the Bladder."

A P H. X.

The Summer Perfpiration much exceeds that in the Winter.

Explanation.] " For the fame Reafon as " warmer Climates exhale more through the " Skin than cold ones, fee *Aph.* VIII. of " *Sanctorius*, with its *Explanation.*"

A P H. XI.

What perfpires in the Day-Time, is half as much more than what goes off by Night.

Explanation.] " For the Reason see *Aph.* " VIII. and many of *Sanctorius*'s, in *Sect.* IV. " especially."

A P H. XII.

The Diminution of Perspiration by Night does not increase the Quantity of Urine; nor does an Increase of Urine by Day, lessen the Quantity perspired at that Time.

Explanation.] " This can only happen in " some certain Circumstances, where the re- " tained Matter causes the Humours to be " more viscid; for otherwise, there will " certainly the more pass by Urine, as it is " manifest in various Instances, where an " increased Quantity of Urine is a very salu- " tary Means of discharging what was other- " wise obstructed, as by external Cold. The " Increase of Urine indeed does not so rea- " dily diminish Perspiration in the Night, " because a warm Bed will certainly draw " out as much as the Pores can conveniently, " and in a natural State, discharge; tho' a " Continuance of such an Increase will cer- " tainly diminish in the other Respect, or " else a Person will soon fall away in Sub- " stance, and grow into a distemper'd State."

A P H. XIII.

If we equally divide the Day between Sleep and Waking, one Day perspires thirty Ounces and 97 decimal parts, or seven Drams.

A P H.

A P H. XIV.

If a Perſon lies in Bed but eight Hours, the moſt of one Day's Perſpiration will not exceed three and thirty Ounces.

Explanation.] "The leſs a Perſon perſpires "in Bed, undoubtedly the more will come "away in the Day-Time, unleſs the retained "Matter weakens the Spring of the Solids, "by laying upon them too great a Load, "and thereby occaſions a Viſcidity, or *Lentor*, "which often happens."

A P H. XV.

If the Day be in like manner divided, the Urine will amount to thirty-nine Ounces. The Quantity perſpired, is, *cæteris paribus*, proportionate to the Degree of Heat.

Explanation.] "The former Part of this "*Aphoriſm* agrees not well with the V. *A*-"*phoriſm* above, where the Quantity by "Urine is aſſigned but twenty-four Ounces. "In the latter Part, whether the Author "means the natural Heat, or the Heat of the "Weather, it is much the ſame for Truth, "becauſe both thoſe Cauſes much influence "the Quantity perſpired: But the natural "Heat in particular, certainly determines "their Diſcharge to be greater or leſſer, "juſt as that exceeds or decreaſes, becauſe "the digeſtive Faculties, and the Fluidity of "the Juices are govern'd thereby, the grea-"ter Heat always giving the greateſt Mo-"tion and Attrition, and thereby breaking "the Humours ſo ſmall, as to fit them

"in greater Abundance for Exhalation by "insensible Steam.

Dr Keill *is not here guilty of any Inconsistency, but Dr* Quincy *is himself mistaken. Dr* Keill *says, in the V. Aphorism, that the Urine discharged in one day is two pound and almost six ounces, which is near thirty-eight ounces, not twenty-four, as Dr* Quincy *has here quoted him.*"

A P H. XVI.

The Quantity of Urine is in Proportion to the Quantity of Liquor drank. See *March* 8, 9, 10, 11, 12, *June* 19.

Explanation.] "The Cause of this is very "manifest, because the greater Quantity of "Fluids is taken in, the more will be supply'd to all the thinner Secretions, but "particularly that of Urine, which drains "off almost all the Liquids that are left "too gross, to be sent away through the "Pores of the Skin. And this appeared "also plain by the Author's own Experi- "ence; for by his Calculation in the Table, "he made three Pounds, or upwards, of "Urine in a natural Day, which is almost, "if not quite, double the usual Quantity; "but those Days it is observable, that he "drank largely of Bath Waters, and also "of Green Tea, the latter of which is a "Liquor that runs off very fast by Urine."

A P H. XVII.

In Summer the greateft Perfpiration is almoft three Pounds, and the leaft Perfpiration in Winter about a Pound and half. See *June* 13 and *January* 20.

Dr Quincy *has erroneoufly tranflated* half a pound *inftead of a* pound and half: *the word in the Original is* fefquilibra.

Explanation.] " This appears from the " Doctor's Experience; for in the Middle " of *June* his Journal mentions near three " Pounds perfpired, although it was wet " Weather, which is often fome Obftruc- " tion thereunto: And in *January* the 20th, " it was very little, but he fays indeed, that " he had then taken Cold from having his " Head fhaved; which Circumftances are " always attended with a diminifhed Per- " fpiration, and denote a *Plethora*; where- " as the true Eftimate of thefe Affairs, is " to be made in a healthful State."

A P H. XVIII.

About thirty-three Ounces is the mean Quantity perfpired; and therefore we have laid them down as a Standard of one Day's Perfpiration, drawn from the preceding Tables.

A P H. XIX.

The Latitude of a natural Perfpiration is from about a Pound and half to three Pound, and beyond thefe Extreams a healthful Perfpiration is never extended, but inclines fome-

times to one, and sometimes to the other, according to the various Condition of the Body.

Here again Dr Quincy *translates* sesquilibram *half a pound.*

Explanation.] "This is very agreeable to "the greatest and least healthful Standards, "which *Sanctorius* speaks of, between which "Extreams Health may be preserved, but "further, the Constitution must degenerate "into a distempered State."

APH. XX.

Perspiration may be carried beyond its natural Extent by Heat and Exercise, or by Cold and Rest.

Explanation.] "Heat and Exercise will "break and fuse the Humours beyond "Measure, and cause more to be exhaled "through the Skin; whereas Cold and "Rest, will make the Juices more viscid "than natural, and by that means cause "less to go off by Perspiration than is conve-"nient and necessary to a healthful State."

APH. XXI.

Sometimes two, three, or four Ounces, will be carryed off in Perspiration, by Heat, Motion, and Exercise, in the space of one Hour. See *September*, *October*, and the Observations of various years. *August* 3, 5, 15. *June* 24, 25.

Explanation.] "How these Causes increase "Perspiration is manifest from what hath "been already said: and the Author's own "Experience hath confirm'd it; for by his "Tables it appears, that in *August*, when "the

" the Weather was hot, and the Pulſe beat
" 92 Strokes in a Minute, one Pound was
" perſpired in four Hours after Dinner; and
" in *June*, with Exerciſe, a yet greater
" Quantity exhaled. The ſame Effect had
" much riding in the Month of *October*."

A P H. XXII.

The greater Perſpiration is made by Motion and Exerciſe, ſo much the leſs it is in the following Hours, when the Body is at Reſt. *Sept.* 14, 23. *Obſ. Var. Aug.* 3, 4, 5.

Explanation.] " Becauſe ſuch Agitation forces away all that is broke ſmall enough for Expulſion, and ſome Time is required, before the digeſtive Faculties can break more, when at Reſt, fine enough to go off the ſame Way; and therefore after Exerciſe, and a plentiful Perſpiration, muſt it neceſſarily be leſſened for ſome time. This alſo the Doctor found by computing the Quantity waſted after riding, and what paſſed off in the following Hours."

A P H. XXIII.

By Cold and Reſt, ſcarce half an Ounce will waſte by Perſpiration in one Hour. See *Feb.* 18. *Obſ. Var. Jan. Feb.*

Explanation.] " Both theſe cannot but have an oppoſite Effect to Heat and Motion; and the Reaſons why *thoſe* increaſe Perſpiration, makes it plain why *theſe* leſſen it."

A P H.

A P H. XXIV.

Perspiration is increased by riding. See *Sept. Obs. Var. Tab.* I. *Feb.*

Explanation.] " If all Exercise promotes " Perspiration, as abundantly appears already, " riding cannot miss of the same Effect, be- " cause it is one of the most advantageous " that can be used, so that it be moderate; " for otherwise, instead of shaking off redun- " dant Fluids, the Solids will be rendered " over tense, and Perspiration lessened, as " in many Places it hath been proved of " immoderate Exercise at any time."

A P H. XXV.

Perspiration will arise in one Hour to a pound and half from bathing in warm Water, norwill it afterwards be diminished by such an Increase.

Here Dr Quincy *again translates* sesquilibram *half a pound.*

Explanation.] " Warm Bathing not only " draws off a great deal of perspirable Mat- " ter, by relaxing and widening the Pores " upon the Surface of the Body, but also " helps to fuse and render thinner the re- " maining Juices, by its Warmth, and the " Introduction of some Parts thereof into the " Course of Circulation, as *Bellini* hath pro- " ved, and is at large explained under the " II. *Section* of *Sanctorius*'s *Aphorisms*, towards " the Beginning. So that the Reason why " the subsequent Perspiration does not de- " crease, is manifested from the additional " Quantity of perspirable Matter that is

" made by Bathing, to keep it on for the " future. And this plainly points out in " what Cafes and Conftitutions this Remedy " is beneficial, and when it may prove other- " wife."

A P H. XXVI.

That Perfpiration which is encouraged by a Winter's Fire, is not inferior to what will rife from the Sun in a Summer's Day. *Feb.* 15. *Obf. Var. Tab.* I. *Jan. Feb.* 15.

Explanation.] " This is fupported by the " Doctor's own Obfervation, after fitting a " whole Day in *January* by the Fire-fide; " but it does not feem very practicable fo to " circumftance the Warmth of a Fire, that " it fhall diffufe fuch an equal and natural " Warmth as that of the Sun; becaufe it " may by too near Approach give a Tenfity " and Drynefs to the Fibres, which will hin- " der Perfpiration; and therefore muft fuch " Endeavours to promote it be carefully at- " tended with due Quantities of Diluters, " and fuch Coverings of Cloaths, as may " keep a Moifture upon the Skin."

A P H. XXVII.

A Perfon perfpires the lefs for being over wearied with Exercife. *Aug.* 12, 20.

Explanation.] " This is explained under " many *Aphorifms* of the V. *Section* of *Sancto-* " *rius.*"

A P H. XXVIII.

Frequent toffing about in Bed hinders Perfpiration. *Sept.* 15.

Explanation.]

Explanation.] "This is alſo exactly the "ſame as the LI and LXX. *Aphoriſms* of "*Sanctorius*, in his I. *Section*, whereunto "the Reaſons for it are annexed."

A P H. XXIX.

The Motion of a Body in Action, and the Agitation of a Perſon in Bed, have very different Effects; *this* hinders Perſpiration, and *that* promotes it.

Dr Quincy *in his Tranſlation has miſplaced the words* hinders *and* promotes; *he ſays* this promotes Perſpiration, and that hinders it, *which is contrary to Dr* Keill's *Expreſſion, and to Obſervation.*

Explanation.] "This again is demonſtrable "from many *Aphoriſms* of the V. *Section*, "compared with the LI. and LXX. of the "I. *Section.*"

A P H. XXX.

They perſpire the leſs who ſleep uncovered and in the open Air; and when Sleep retards the Separation both of Urine and Perſpiration, it certainly renders the Body weaker and heavier than it ought to be.

Explanation.] "The firſt Part of this is "manifeſt from *Sanctorius*'s XXXVI. *Aphoriſm* of the II. *Sect.* and when Sleep there- "fore, which is ſo great a Promoter natural- "ly of the thinner Secretion, is ſo circum- "ſtanced, that it hinders them, as in this "Caſe, it cannot but render the Body more "languid, both for want of ſufficient Recruit "of Spirits into the Fibres, and alſo by the "addition of an Overload from the Reten- "tion

" tion of what ought to be caſt out, both
" which cauſe the Body to be heavier, the
" former *relatively*, and the latter *abſolutely* ;
" which Diſtinction ſee explained under
" *Aphoriſm* XXIX. of the I. *Section*."

A P H. XXXI.

The more a Perſon perſpires in the Day-Time, the leſs will he perſpire at Night. *Obſ. Var. Tab.* I.

Explanation.] " How an increaſed Eva-
" cuation at one Time, will leſſen the ſame
" Evacuation afterwards, depends upon Cir-
" cumſtances that make a great Difference ;
" for, *cæteris paribus*, it always diminiſhes
" the ſucceeding Evacuation in proportion to
" its own Exerciſe ; but where the Cauſe of
" a greater Separation is the Cauſe alſo of pre-
" paring more of the ſeparable Matter, as
" is the Caſe of warm Bathing in the XXV.
" *Aphoriſm* above, there will not follow a
" leſſer Separation than natural ; and where
" the Cauſe of Separation is ſuch as preſſes
" out only what is already fit for Expulſion,
" as in moſt Exerciſes, the following Eva-
" cuation muſt decreaſe, as appears by many
" of the preceding *Aphoriſms* ; and without
" regard to this Diſtinction, many Places
" herein may ſeem to contradict one another,
" and cannot be well underſtood."

A P H. XXXII.

Perſpiration in the Night-Time is ſometimes leſs by half than uſual, without being attended with any Inconveniences. See *July* 2 29. *Aug.* 8. *Sept.* 5, 24, 26. *Feb.* 19.

Explanation.]

Explanation.] " By the Doctor's Register
" it appears, that he perspired but four Oun-
" ces the 19*th* of *February* at Night, and he
" says there was no manifest Cause for such a
" Diminution, nor was it followed by any
" Disorder. But in all such Cases Nature
" must have been either much exhausted be-
" fore, so that what would otherwise make
" perspirable Matter, remains still of some
" use in the Course of Circulation, and goes
" into Nourishment, or else some other Eva-
" cuation is increased in Proportion to the
" Quantity retained; unless the Strength of
" the digestive Powers afterwards are able to
" throw off such Accumulation of obstructed
" Matter by an enlarged Perspiration; but
" even while that is doing a Person would feel
" some Alteration for the worse."

APH. XXXIII.

Friction upon the Skin neither promotes nor lessens Perspiration. *Aug.*

Explanation.] " This seems to be grounded
" upon rubbing with a Hair-Brush, one Night
" going to Bed, until the Skin looked red,
" without causing any increase of Perspiration
" that Night; but it is to be remarked, that
" there is a vast deal of difference in using
" Friction, after a Day's Exercise has thrown
" off all the perspirable Matter fit for Ex-
" pulsion, and in a Morning, when a Night's
" Digestion has prepared in readiness a great
" Quantity fit to be drawn off by any Sol-
" licitation. In the former Case the Flesh-
" Brush will rather prove such a *Stimulus* as
" will render the Fibres more tense, and

" prevent

"prevent their falling into that relaxed Con-
"dition as is requisite for sound Sleep; and
"likewise by no means increase the Quantity
"of perspirable Matter, because the Day's
"Action has already done that as far as is
"possible; but in a Morning the same means
"will, by shaking the Fibres, draw out a
"great deal, which by the previous Night's
"Digestion lies ready broke small enough
"for Transpiration. See further under
"*Aphorism* LXXIV. of the I. *Section* in
"*Sanctorius.*

A P H. XXXIV.

An Obstruction of Perspiration is not the Cause of a Cough. *Jan.* 20. *Obs. Var. Feb.* 15. *Tab.* I.

Explanation.] "This *Aphorism* Dr *Keill* bestows afterwards a whole Dissertation upon, "in order to explain and prove it; and in that "he disallows the retained and perspirable "Matter, upon taking Cold, to be the Cause "of a Cough; and endeavours to prove, that "it is from a Mixture of frigorifick Particles "with the animal Juices; but this Distinc- "tion does not to me seem to be of any great "moment. The Doctor's Register, or Ta- "bles, set forth, that *Jan.* 20. he caught "Cold from having his Head shaved; upon "which immediately follow'd a Cough; and "that on *Feb.* 15. he slept with his Head "bare; whereupon followed a Pain of the "Tonsils, and a great Cough: And in both "the Instances it appears that Perspiration "was diminished. Now whether this Cough "comes from a *Lentor*, or Viscidity, which

" an Increafe of retained perfpirable Matter " occafions, in the manner that every *Plethora*, or a Redundance of Fluid, will occafion the fame; or whether a Sett of particular Particles taken in through the Pores " from the Air, induces the fame Effect, " from their Quality and not Quantity, is of " no great Importance, as to any thing that " regards the Means of Remedy, and therefore not worth difputing, although probably where Perfpiration is diminifhed by a " cold Air upon the Skin, the Confequences " that may follow of a Vifcidity, a Cough, " and the like, may be owing to a Matter " offending both in Quality and Quantity; " and confequently fome Truth may be on " both fides the Controverfy."

A P H. XXXV.

The Body is in equal Times, more diminifhed by Sweat, than by infenfible Perfpiration. *July* 24, 26.

Explanation.] " Much Sweat may in many " Inftances render the Body *abfolutely* lighter, " than infenfible Perfpiration would do, by " carrying off a greater Quantity of Matter; " but it can be feldom practis'd, without " wafting fo much at the fame Time, of " Spirits, as to render the Body *relatively* " heavier, that is, weaker."

APH. XXXVI.

If the Weight of the Body is diminished by large Evacuations, it soon returns to its usual Weight, either by a greater Quantity of Food, or its longer Retention, or by an Attraction of moist Air. *Aug.* 3, 5, 27. *Sept.* 3. *Obs. Var. Sept.* 24. *Tab.* III. *Dec. Tab.* IV.

Explanation.] "The Author here refers to "many Observations of Facts recorded in his "Tables, and takes Notice particularly of "the 27*th* of *August*, that he wasted an un-"common Quantity by Exercise and Riding, "but that in the very next Day, from five "Pounds of Meat and Drink taken in, he "wasted in twenty-four Hours Time but a "little above half that Quantity, so that two "Pounds was retained as a Recruit for the "previous Diminution. In Cases therefore of "this Nature, the same Care ought to be tak-"en in chusing a light Food, as after wasting "by Sickness, because any other cannot but "generate Crudities, accumulate bad Hu-"mours, and make Obstructions. As for "the Attraction of a moist Air by a Body so "emptied, it seems very probable, that there "may be a greater Aptitude in the Pores to "introduce such Moisture, but that it can be "received in any considerable Quantity, and, "as the Author mentions, in one Night, "*December* 27, to eighteen Ounces, I can-"not well apprehend; nor does it seem to me "practicable, for the Constitution to dispense "with such an Addition of cold Moisture, "without very great and unconquerable Dif-"ficulties."

A P H. XXXVII.

Purging Medicines do not hinder Perspiration. *Feb.* 3. *Aug.* 3, 5. *Obs. Var. Sept.* 26. *Tab.* III.

Explanation.] "This cannot be understood "in an unlimited Sense; for in many Cases "Purging will lessen Perspiration, that is, "where they either diminish greatly the "Quantity of animal Juices, as strong Ca-"tharticks will do, or where they weaken "the digestive Powers; the Instances there-"fore the Doctor refers to in his Register, "where he one Time purged with *Jalap*, "and another with *Elix. Salutis*, will not "conclude, that in no Cases purging will not "lessen the cutaneous Secretion; and when "this can be practised without such an Effect, "it is a manifest Sign that the Purge has car-"ried off only an Over-load or Redundance "of Humour, and left the Animal Func-"tions in as good, if not a better, Condition, "than before."

A P H. XXXVIII.

The Quantity of Meat and Drink, is to the Quantity perspired, as 2.2 to 1.

A P H. XXXIX.

If the Meat and Drink in one Day be four Pound and an half, the Perspiration of that Day will be two Pounds, the Urine as many Pounds and five Ounces, and the Quantity by Stool, three Ounces.

Explanation.]

Explanation.] "Thefe may be compared with "the preceeding *Aphorifms* of this author, "and the beginning of *Santorius*'s firft Sec- "tion, wherein the Differences may eafily "be accounted for, from what is there faid "about the Differences of Climates."

APH. XL.

The natural Difcharges are not in Propor-tion to the Weight of the Body, but the Quantity of Diet taken in.

Explanation.] "For we have many In- "ftances of lufty People, who eat and drink "not fo much as lefs; if the Evacuations "therefore were in proportion to the Bulk, "fuch Bodies would foon be reduced to the "fmalleft fize. And whereas the digeftive "Powers being the main efficient Caufe, "which determine the Conditions and Quan- "tities of Evacuation, our Computations are "to be taken from thence; and as the Ap- "petite is commonly anfwerable to fuch "Powers, and the Quantities taken in, fo "the Difcharge in a natural State cannot but "be anfwerable thereunto."

APH. XLI.

That is the Proportion of Diet fuitable to every one, by a Diminution of which the Body would leffen, or increafe upon its Excefs.

Explanat.] "Where therefore a Perfon "increafes in Bulk, or leffens, and it cannot "be affign'd to any other manifeft Caufe,

" it is very probable from too plentiful, or " too ſparing a Diet; and every one is able " how to regulate any Diſorder from this " Original."

A P H. XLII.

The Proportion of daily Food ſuitable to a Body in the forementioned Circumſtances, is about four Pounds; for this quantity commonly brings the Body every Day to the ſame Standard of Weight; but leſs ſinks it, as a greater Quantity increaſes it.

Explanation.] " The healthful Standards " have been often explained in *Sanctorius*'s " Aphoriſms; and what Quantities of Food " will beſt preſerve ſuch a Standard, is beſt " within every one's own Experience; be- " cauſe ſome will digeſt off a great deal more " than others, tho' this ſettled by the Author, " is very likely to be the Quantity conve- " nient to moſt People."

A P H. XLIII.

If the Quantity of Food be greater or leſſer than needful, then it will not anſwer to the Quantities evacuated; for whether we eat more or leſs, Nature always keeps a certain Rule in Evacuation.

Explanation.] " That is where the dige- " ſtive Powers keep in their natural Force; " but it is pretty difficult to go into Ex- " ceſs of Feeding either Way, without af- " fecting thoſe Powers, and therefore will " that Rule, which the Author ſpeaks of " here, be often broke, and the Quantities

" evacuated

" evacuated be made moſt commonly to bear " ſome Proportion to the Quantities taken " in."

APH. XLIV.

This Rule of Evacuation hath a certain Latitude, and the more every Conſtitution will admit of that Latitude, the leſs liable will it be to Diſeaſes.

Explanation.] " This is manifeſt alſo from " many of *Sanctorius*'s Aphoriſms, and what " hath been ſaid in their Explanations. Com- " mon Experience likewiſe informs us, that " the more yeilding a Conſtitution is to ſuch " ordinary Accidents, as will in ſome Mea- " ſure increaſe, or diminiſh, or change the " Evacuations, the much eaſier is ſuch a one " preſerved in a State of Health; whereas " thoſe who ſeldom vary from a conſtant " Standard and Condition of Evacuation, " are the moſt diſordered when they do ſo: " For that robuſt Tenſity of the Fibres, " which makes ſtrong People the leſs liable " to Accidents, and the leaſt changed by " them from a healthful Standard, whenever " they are put out of Courſe, are more " unruly, and much ſooner break into " irreparable Diſorders; the Greatneſs of " their Springs being much leſs under Sub- " jection in many Caſes to the means of " Remedy, and much more miſchievous to " the animal Functions when excited into " irregular Motions. In the whole therefore, " a Conſtitution that can go into the greateſt " Deviations, is moſt ſafe from Accidents " and ordinary Diſtempers."

A P H. XLV.

By how much any one exceeds the due Proportion of Food, fo much he increafes the Bulk of his Body, unlefs fome violent Evacuation follows. For fince there is a certain Rule for Evacuation, not able to throw off every Increafe of Food; it is neceffary that what abounds, fhould either go into Nourifhment, or if the Conftitution cannot fo difpenfe with it, there muft arife either fome Difeafe, or follow fome preternatural Evacuation.

Explanation.] "This is little more than a "Comment upon fome of the former, and "wants no *Explanation*, as is alfo the fol"lowing."

A P H. XLVI.

But how much a Perfon abates of the due Quantity of Food, fo much Strength and Weight will he lofe; and the Veffels being emptied Death itfelf will at laft enfue.

A P H. XLVII.

The Rule for eating to every Body, is a natural Appetite; and by this Monitor may every one be advertifed of the Quantity proper to be taken in, without weighing; for Nature never requires more or lefs than is convenient, and the Appetite is proportionable to the natural Evacuations.

Explanation.] "In this is fummed up moft "that is material in the foregoing, and is "of the utmoft confequence for a Perfon to "attend to: For the natural Appetite is cer-

"tainly

"tainly the beſt Guide, both in the Quan-
"tities and Qualities of the Meats and
"Drinks to be taken in; but Perſons muſt
"be careful to diſtinguiſh a *natural* Appe-
"tite from one that is *vitiated* and *debauch-*
"*ed* by Exceſs and over Indulgence. This
"ought to be compared with the XLII
"and XLIII *Aphoriſms* of *Sanctorius*, and
"the Standard of Digeſtion and Excretion
"will be eaſily enough underſtood."

A P H. XLVIII.

Let a Perſon eat much or little, if he keeps the ſame Weight, and has any Ail, it is not from a depraved Appetite.

Explanation.] "For if the eating more or
"leſs was owing to a Diſtemperature of
"Appetite, the digeſtive Powers would alſo
"be in fault, and the Body not be kept
"up to the ſame Bulk."

A P H XLIX.

Oyſters give the greateſt Nouriſhments, not becauſe they are the leaſt perſpirable of all Food, but alſo becauſe they hinder the Perſpiration of other Meats. For leſs is preſpired thoſe Nights where Oyſters are eat for Supper, than where there was no Supper at all.

Explanation.] "It requires good Attenti-
"on to diſtinguiſh between Things that
"leſſen Perſpiration, by being uncapable of
"Reduction, by the digeſtive Powers, to
"a fineneſs ſuitable for ſuch Diſcharge, and
"ſuch as leſſen Perſpiration by their fitneſs
"for Lodgment in the Habit, and making

" Matter for Nouriſhment. The firſt are
" Subſtances extremely hard and viſcid, that
" cannot be broke fine enough to go into
" the laſt Stages of Circulation, but are
" thrown out of the Body by ſome of the
" greater Outlets, as the *Anus* or *Kidneys* ;
" but the latter are ſuch as will eaſily break
" ſmall enough to go into the fineſt Paſſages,
" but are even then of that light adheſive
" Nature, that they eaſily lodge upon, and
" make a Part of the Paſſages themſelves,
" eſpecially where there are Interſtices to take
" them out of the perfluent Current; and by
" this Property, theſe not only leſſen the
" Quantity to be perſpired at that time, but
" alſo wrap up and incloſe other fine Particles,
" that come in their way, which might elſe
" fly out through the Pores; and this Diffe-
" rence is manifeſt in the Texture of thoſe Sub-
" ſtances which common Experience ſhow to
" be very little, or very much nouriſhing; the
" firſt are very hard, rigid, or tough; and
" the latter are very ſoft, yielding, and adhe-
" ſive. The Author builds this *Aphoriſm* about
" Oyſters, upon many Inſtances of his own
" Experience to which he refers in his Tables ;
" whereby it appears, that he always per-
" ſpired leſs after a Supper of theſe Fiſh:
" But where there is too great a *Plethora*, or
" the digeſtive Powers are very weak, care
" muſt be taken not to indulge too much
" with ſuch Food, becauſe of their Aptitude
" to run into Corruption and Fermentation,
" as *Sanctorius* cautions in many Places; and
" in what Caſes likewiſe ſuch Subſtances are
" to

"to be chosen, has been largely explained
"under these *Aphorisms*."

APH. L.

Punch is both Diuretick and Sudorifick. *Jan. Nov. Dec.*

Explanation.] "For this the Author refers
"to Instances of his own Experience; but
"might have also appealed to the Experience
"of all who have used it: Besides the Nature
"of the Materials of which it is made, being
"chiefly Spirit, an Acid, and a common
"Diluter, would demonstrate to us the Ne-
"cessity there is for its having those Ef-
"fects, more or less, wherever it is used.

APH. LI.

Drinking small Liquors promotes Urine, but very little affects Perspiration. *Febr. Mar. June. Nov.*

Explanation.] "Because they very natu-
"rally, with a little Alteration, make the
"serous Part of the Blood, and wash off by
"the Kidneys; but an aqueous Fluid is too
"gross to be comminuted fine enough to go
"into smaller Passages, and therefore has
"it nothing to do in those Parts, where the
"last Digestion is concerned and where the
"perspirable Matter is chiefly made."

APH. LII.

Perspiration is not so much affected by Meats, as Urine is by Drinks; or Urine so much affected by the Seasons of the Year as Perspiration.

Explanation.] "Because that particular Con-
"coction

" coction wherein, the perspirable Matter is
" chiefly prepared, lies furthest off the In-
" fluence of what is taken in at the Mouth;
" whereas the Liquors we drink are soon
" strained into the Blood, from whence they
" immediately affect the Parts which separate
" the Urine; and that Urine is not so much
" influenced by Changes of Weather, as Per-
" spiration, is very plain; because such Chan-
" ges immediately affect the Surface of the
" Body which lies open thereunto, and upon
" which the Pores venting the perspirable
" Matter are dispersed; whereas the Urine is
" prepared and separated in the middle of the
" Body, where the Parts are fenced and
" guarded from the immediate Contacts of
" Air, and the Influences of different Seasons."

APH. LIII.

There is no difference perceivable between Perspiration before and after Dinner, nor does going to Bed without a Supper, diminish Perspiration.

Explanation.] " That is, where every thing
" is managed with Moderation and Tem-
" perance, for a little Excess will make an
" Alteration herein, as it appears by many
" of the preceding *Aphorisms.*

APH. LIV.

The Pulse is much quicker in the Evening than in the Morning, and is accelerated by eating Dinner.

Explanation.] Because the Day's Exercise
" has wasted a great Quantity of the animal
" Fluids, and left less Resistance to the con-
tractile

" tractile Fibres; besides that additional Ten-
" sity which the Fibres obtain, whereby they
" vibrate quicker and stronger: Both these
" may be in the Case of common Hecticks.
" That a Meal will quicken the Pulse, is
" both from the additional Quantity of
" Spirits, which thereby is strained into the
" Fibres; as explained in the *Essay of an
" animal Fibre*, which see; and the Resi-
" stance which a full Stomach gives to the
" descending Blood, whereby the Head has
" a greater Share, and consequently are there
" more Spirits separated into the Nerves
" which move the Heart, and influence the
" Pulse of all the Arteries."

APH. LV.

There is an easy and a continual Egress and Ingress of Air through all the Pores of the Body.

Explanation.] " This may be conceived
" from what hath been before said under the
" first *Aphorisms* of *Sanctorius*'s second *Section*,
" concerning Water in bathing."

APH. LVI.

Those watery Particles which float about in the Air like Vapours, being attracted by the Skin, are mixed with the Blood, and add to the Weight of our Bodies. See *Tab.* IV. *Dec.*

Explanation.] " For this the Author refers
" to his Tables, where he says, that eighteen
" Ounces was gained from the moist Air in
" one Night. But how this can be ascertained
" I cannot yet conceive, nor how so great a

" Quantity can be dispensed with, without " great Mischiefs; tho' the following seems " probable, that

APH. LVII.

Bodies emaciated by Sickness, or emptied by Evacuation, draw more moisture from the Air than full ones.

Explanation.] " Because such Emptiness " cannot but add to that Faculty, which ad- " mits the Introduction of any Fluid into the " Body through the Pores of the Skin."

APH. LVIII.

We attract more in a cloudy Season, than a dry one; more in the Night than in the Day more sleeping than waking; and from hence it is, that the Day's Perspiration is greater than that in the Night.

Explanation.] " Wet Weather, and the " Night Season conduce to this more than the " Day-Time, and a dry Air, by leaving a " Moisture upon the Skin, and relaxing it; " but there are other Causes concurring to " make the Nights Perspiration less than that " in the Day-Time besides this, as appears " by many Places in *Sanctorius*'s *Medicina* " *Statica.*"

APH. LIX.

Garments of all Kinds draw the Moisture of the Air; and such Attraction in Garments of equal Surfaces is as their Weights.

APH. LX.

The Attraction of Garments of equal Weights is as their Superficies.

APH.

APH. LXI.

The Attraction of Garments of the fame Stuff, are in a compound Proportion of their Weights and Superficies.

Explanation.] " Garments in general do this
" as all dry Bodies abforb Humidities that are
" contiguous to them, and may be eafily
" enough underftood by the common Opera-
" tion of Filters. And the Proportions in
" which they attract in the recited Conditions,
" is demonftrable at firft View; from the
" Principles of all Reafoning in fuch Cafes."

APH. LXII.

Thofe Garments which are made of animal Subftances, attract more than thofe made from Vegetables.

APH. LXIII.

There is the fame atractive Power in Silken as in Woollen Garments, if in all other Refpects they agree.

APH. LXIV.

Leather draws more than any other Garment.

APH. LXV.

Linnen draws the leaft of any Cloaths.

APH. LXVI.

Black Cloaths, *cæteris paribus*, draw the leaft Moifture of any.

Explanation.] " What that particular Dif-
" pofition of the Pores and Fibres in thefe
" Cafes,

"Cafes, that gives this Difference, is, can-"
"not very certainly be affign'd; but this"
"Rule in general will hold, that where the"
"Pores are moft numerous and fmall, and"
"the Fibres moft foft and yielding, there the"
"Attraction will be greateft, as in common"
"dreffed Leather, which is very foft and"
"fpungy; and where the Pores are wideft"
"and the Fibres hard, as in Linnen, there"
"the attractive Powers will be weakeft. And"
"what is here faid of Garments attracting"
"Moifture from the Air, is alfo true of their"
"attracting Moifture from the Body, and"
"therefore may fuggeft a very good Hint in"
"what Cafes and Circumftances they are to"
"be ordered. Such as draw moft, are the"
"leaft to be ufed where the Body has leaft"
"to fpare, and indulged in grofs Habits"
"that are full of Humours, and fuch as"
"draw leaft to be regulated by the ob-"
"vious Difpofitions and Exigencies of the"
"Patient."

What effect the Phafes of the Moon, Weight of the Air, and Courfe of the Winds, have upon Bodies, muft be referred to future Opportunities.

DISQUI-

DISQUISITION
The Firſt.

An obſtructed Perſpiration is not the Cauſe of catching cold.

HUman Underſtanding is never more ſubject to Error, than in thoſe things, which at firſt ſight have the Appearance of Truth; for the appearance of Truth being obvious, caſts a thick Shade upon Truth itſelf lying hid in Darkneſs, and interpoſes itſelf as an Obſtacle to our Inquiries. There is no ſtronger example of this, than the Opinion of Phyſicians of the Cauſe of a *Cough*, which ſeemed ſo evident, that it has never yet been called in queſtion, but has obtained the Conſent of the learned in all Ages. For as nothing was more certain, than that Perſpiration is leſs in a cold Air than in a hot one, and as the unlearned as well as the learned perceive, that they have catched cold from the Air entring the Pores thro' the Skin, it ſeemed to be no bad or abſurd Concluſion, that the Moiſture, which uſed to be carried off by inſenſible Tranſpiration, being detained within, from a cold Air conſtringing and ſhutting up the Pores of the Skin, and being fallen

fallen upon the Lungs, Throat, and Glandules of the Noſe, cauſes the Symptoms of what we call *Catching Cold.*

But how far this Concluſion is from the Truth, the preceding Obſervations plainly ſhew; for on that Day in which I catched cold, and on ſeveral following Days, in which I was grievouſly troubled with a Cough, I found no Diminution of Perſpiration. Experience itſelf therefore contradicts this eſtabliſhed Opinion, which has long been univerſally received; which alone is ſufficient to cauſe thoſe, who are not tenaciouſly addicted to their own Opinion, to give up this Doctrine; but if we examine it farther by the Balance of Reaſon, we ſhall find that it was firſt admitted on very ſlight Grounds.

For in the firſt place it is granted, that a *Cough* often ariſes from Air coming thro' a ſmall Chink, and driving ſwiftly againſt a ſmall Part of the Body, the Neck for inſtance. Suppoſe that Part of the Skin expoſed to the Air the twentieth Part of the whole; if we ſuppoſe the Perſpiration to be entirely ſuppreſſed in that Part, that Suppreſſion would be alſo a twentieth Part of the whole Perſpiration, but ſo much and more is one day's Perſpiration often found to fall ſhort of that of the preceding day, without any Cough or increaſe of another Secretion.

In the ſecond place, let it be ſuppoſed that a tenth Part of the Perſpiration be kept in by *Catching Cold*, that is, in one Day's Time, let four Ounces of that Humour, which ought to have been drawn from the Maſs of Blood, be added to it. Now the Quantity of Humour

mour ſeparated by any Gland (the Blood remaining in the ſame State) is as the Quantity of Blood brought to the Gland, wherefore the Quantity of Humour ſeparated by the Glands of the Noſe or Lungs, after catching cold, will be to the Quantity ſeparated by the ſame Glands before catching Cold, as the whole Maſs of Blood increaſed with four Ounces to the whole Maſs of Blood; that is, (if we ſuppoſe the Blood to weigh 25 pound) as 304 to 300, which ſurely is ſo little, as to be altogether inſenſible.

If we ſuppoſe the Pores of the whole Skin to be ſhut up by Cold, ſo that the Maſs of Blood be increaſed forty Ounces, in this Caſe the Quantity of Humour ſeparated from any Gland in it's natural State, will be to the Quantity preternaturally ſeparated, as 15 to 17. But the Quantity of Humour flowing thro' the ſaid Glands, on catching Cold, ſix times, nay more than ten-times, exceeds the Quantity naturally ſeparated, as appears to any one by frequent Experience; wherefore the ſtopping of the *Effluvia* of the Skin can by no means be ſufficient to generate ſo great a Quantity. Here I have ſuppoſed the Perſpiration to be ſtopped a whole day, whereas we ſometimes are afflicted with a Cough, if only a ſmall part of the Body be expoſed for a little while to a cold Air. Beſides the Maſs of Blood is calculated at 25 pound, but it is certainly ſo much heavier, that if all the Perſpiration was to be entirely ſtopped for ſeveral days, yet the increaſed Maſs of Blood could not ſenſibly change the Quantity of Humours ſeparated by the other Glands.

From which it abundantly appears, that neither Perſpiration is diminiſhed by catching cold, nor that Perſpiration being diminiſhed cauſes a Cough, nor that it can ſupply the Humour to a Cough. Since therefore a Cough does not proceed from the Quantity of Blood being increaſed, it muſt neceſſarily proceed from it's Quality being altered; which Change is cauſed by cold Air; not by ſhutting the pores of the Skin, but by mixing itſelf with the Blood, and increaſing the *Copula* of ſome of the Particles of Blood, by it's frigorifick Particles, the ſame perhaps, or like thoſe by which it congeals Water; ſo that the Humour which is formed by theſe *Copulæ*, flows in a more than uſual Quantity upon the Glands of the *Lungs*, *Throat*, or *Noſe*.

DISQUISITION

The Second.

Of the attracting Force of an animated Body.

THO' the Monuments of that ancient Learning, which flourished amongst the Oriental Nations, have perished many Ages ago, and none of them have come down to us from the Greeks without being mutilated; yet may we form no vain Conjecture from the confused Fragments, that the *Chaldæans* and *Egyptians*, and other Oriental People throughly understood the Knowledge of natural Things; and that no other Nation down to our own Times has excelled them in that kind of Learning. In the first Ages of the World, before Men went to war about the Limits of Empire, or Rights of Kingdoms, before any Disputes about Religion arose, the Mind of Man being covetous of Knowledge, was entirely employed on natural things, and Posterity cultivated the Doctrine delivered down to them from their Ancestors, with a Series of Observations. But as the Disciplines of Arts are no less subject to Turns of Fortune, than Empires, and as all human Affairs are continually changed by the fixt Law of Fate, neither Virtue nor Learning can keep their Place; the Philosophy of the Orientals began

to degenerate, before it tranſmigrated to *Greece*. *Egypt* flouriſhed in all kinds of Learning in the Time of *Moſes*, from whom there were almoſt a thouſand Years to *Cyrus*, the Founder of the *Perſian* Empire; to which if we add the Ages before *Moſes*, neceſſary to the Acquiſition of ſo much Science, it will be found a much greater Space of Time, than any other, in which Philoſophy is obſerved to have remained in any Nation. From *Cyrus* to *Alexander the Great*, not only *Egypt*, but alſo all *Aſia*, was vexed with continual Wars, for above two hundred Years; whence thoſe Arts and Diſciplines which had ſhone for many Ages in the moſt flouriſhing State of the Commonwealth, now began to grow dull and languid by the Miſeries of Wars. For who amidſt the Deaths of his Relations, the Plundering of Cities, the Servitude and Slaughter of Citizens, the Conflagration of Temples, the Change of Laws and divine Worſhip, can have a Mind at eaſe, when it has been broken with ſuch Deſolations, and apply it to the Culture of Natural Knowledge? The Care and Favour of Princes was wanting, they were wanting who might be at the Expence of it. The *Magi*, who were the Keepers of Knowledge both divine and human, amongſt the *Chaldeans*, and the Prieſts who had the ſame Care amongſt the *Egyptians*, were ill treated. The Temples of the *Egyptians*, in which the Monuments of Science were kept, were ordered to be pulled down by *Cambyſes*, and the Temple of *Belus* at *Babylon*, on the higheſt Tower of which was an Aſtronomical Obſervatory ſix hundred feet high, was levelled

to

to the Ground by *Xerxes.* To theſe may be added another, and not the leaſt Cauſe of the Loſs of *Antient Philoſophy*, the ſecret way of writing their Learning, not in the uſual and common Characters, but in ſuch as were ſacred and peculiar to the Prieſts, in Hieroglyphicks and Symbols. For as the more exquiſite Part of what the Prieſts knew was wrapped up in theſe Characters, and Concealments, it is no wonder, if in the tumultuary State of the Republick, the Study of the Monuments being intermitted, ſome things ſhould ſlip out of the Minds of the Prieſts, which could never afterwards be recollected; becauſe there could be no certain and determinate Senſe in the Hieroglyphicks and Symbols; and ſo it happened to the more ſubtile, ſacred, and ſecret Learning, communicated from one to another, as it does to Wine poured out of one Veſſel into another, that ſome of the more ſubtile Part was loſt, and ſome Impurity was contracted from the Veſſel. Their Doctrine difficult and obſcure in itſelf, and committed to a few in a ſecret way of Writing, was certainly moſt ſubject to Oblivion. From theſe Reaſons I am perſuaded, that the Philoſophy of the Antients began to grow languid and degenerate, during the Empire of the Perſians. But in this ſpace of Time it was, that the moſt famous of the Greek Philoſophers travelled into Egypt, and the Eaſt, to acquire Natural Knowledge, where they not only obſerved the Ardour of Phyſiology to have grown cold amongſt the Prieſts, but alſo found them, like the Dog in the Manger, lying idly over their Monuments of Science, and averſe from com-

municating the Philoſophy of the Antients. Wherefore, when they had ſpent ſeveral years in humouring the Prieſts, and getting their Favour by Rewards, ſome at length got one Precept of the Antients out of them, and ſome another: but none of the Prieſts opened their Treaſures to them entire, ſo as to give them a general Knowledge of their Philoſophy. Thus as we find none of the Philoſophers to abound with antient Learning, but ſomething ſavouring of Antiquity in each of them, we collect from all together what the Ancients thought on each ſubject. Amongſt theſe *Thales* is famous for diſcovering the Solſtices and Equinoxes, and firſt predicted an Eclipſe of the Sun, but who can be ſo weak as to imagine that the *Egyptians*, who made Obſervations for almoſt twenty Ages, were ignorant of the Equinoxes and Solſtices? Certainly if they were capable of making any Obſervations, theſe which are ſo obvious could not have eſcaped them. The method of inveſtigating Eclipſes depends on Aſtronomical Obſervations, with which *Greece* could not ſupply Thales; for the moſt antient Obſervations of the *Greeks* were later than the lateſt of the *Babylonians*, according to Ptolemy. But when *Babylon* was taken by *Alexander*, *Calliſthenes* found an almoſt continued *Series* of Obſervations from the *Deluge* to that time; and therefore in the time of *Thales*, *Greece* took no pains about Aſtronomy. It is certain alſo that the Prieſts never uſed to let any one ſee their ſacred Monuments, and antient Annals; and, according to *Strabo*, taught only their moſt eaſy Theorems; wherefore *Thales* muſt neceſſarily have learned the Theory

Theory of Eclipſes from them; for the Knowledge of the Antients did not conſiſt in bare Obſervations, as ſome imagine. *Thales* is ſaid to have ſacrificed an Ox to the Gods, on his Diſcovery of the Inſcription of a Triangle in a Circle. A meer trifle! Would he not have thought the Method of predicting an Eclipſe of the Sun more worthy of a Hecatomb, if it had been the off-ſpring of his own Genius and the Reward of his own Labour? Theſe fruits of his Travels *Thales* brought out of *Egypt* into his own Country; and he confeſſed that the fountain of Learning was amongſt the *Egyptians*, when he perſuaded *Pythagoras* to travel into *Egypt* to learn Philoſophy; which Advice *Pythagoras* followed, and having tarried forty Years amongſt the *Egyptians* and *Indians*, brought the true Syſtem of the World, a Reward worthy of all the Labours which he is ſaid to have undergone. Theſe great Men were the Founders of the *Ionic* and *Italic* Sect; of whoſe Diſciples ſome taught that the Heavens are fluid and æthereal; others, that the Stars are ſo many Worlds of a fiery Nature; others, that the Moon is terreſtrial and habitable; others that the Planets are opake Bodies revolving round the Sun, which is placed in the middle of them. Nor were they ignorant of the Phyſical Cauſes of of Celeſtial Motions. For *Anaxagoras* ſaid ὡς ὅλος ὁ οὐρανὸς ἐκ λίθων συγκέοιτο· τῇ σφοδρᾷ δὲ περεδινήσει συνεστάναι, καὶ ἀνεθέντα κατενεχθήσεσθαι. By which Words it appears that *Anaxagoras* meant that the Planets being impelled in a right line, were carried in Orbits about the Sun by the Power of Gravity. Nor was

Pythagoras ignorant that the Gravities of the Planets were to the Sun reciprocally, as the Square of their Diſtances from the Sun, as the famous *Gregory* has ſhewn in his Elements of Phyſical Aſtronomy. That the *Grecians* learned all theſe things of the Barbarians, as they called them, is teſtified by ſeveral Authors, who are moſt converſant in theſe Affairs. What then could they want of the higheſt pitch of Aſtronomy, who knew the Method, of computing Eclipſes, the true Syſtem of the World, and the genuine cauſes of Celeſtial Motions, from the moſt accurate Obſervations of ſeveral Ages?

Tho' *Thales* and *Pythagoras*, who were ſome of the firſt that went into *Egypt*, found the Prieſts very tenacious of their Secrets; yet they learned more and better Doctrines, than any Philoſopher, who followed them. For then was the beginning of the Misfortunes of the *Babylonians* and the *Egyptians*; but afterwards, as the War continually ſpread, Natural Philoſophy, which at firſt ceaſed to proceed, went every day backwards, languiſhed, and at laſt died. For Phyſiology, no leſs than Eloquence, *is the Friend of Peace, the Companion of Leiſure, and, as it were, the Child of a well eſtabliſhed Commonwealth.* The Genius of the *Grecians* was better turned for Moral than for Natural Philoſophy: for they had never any fixt and permanent Kingdom, like the *Egyptians*; but *Orpheus*, who was ſkilled in the wiſdom of the *Egyptians*, firſt gathered Men into Societies, and bringing them from a wild and ſavage kind of life to Humanity and Civility, and in ſome ſort deſcribed Judgments and Laws: and when afterwards ſeveral

Cities

Cities flouriſhed at the ſame time, being Rivals to each other, the chief among them diligently laboured in adorning them with Laws and defending them with Arms. But after *Thales*, who amidſt the Cares of the Commonwealth, thought the Study of Nature not unworthy of the greateſt Man, ſome Philoſophers aroſe, who, whilſt they endeavoured by ingenious *Fictions* of their own brains to deprive the *Egyptians* and *Chaldeans* of their Fame, acquired by a long Obſervation of Nature, loſt great part of the antient Wiſdom of the Eaſt; which gave occaſion to *Socrates*, who deſpiſed Natural Knowledge, to call off the Philoſophers to the Study of Morality, common Life, and Politicks. In the Writings of theſe Philoſophers, ſome ſparks of the antient Phyſiology appeared, which Ariſtotle obſcured with empty Words, and eſtabliſhed a Phyſiology, ſubtile in the Explanation, not of Things but of Words.

Democritus having travelled over all *Aſia*, brought the Doctrine of *Atoms* into *Greece*. Of this learned and ſagacious Man, and perfect, as *Cicero* teſtifies, in Geometry, if the Phyſical Works were remaining, we ſhould find many things no doubt confirmed by the Teſtimony of the Antients, which now altogether lie hid, or are hardly admitted without much Heſitation. His Contemporary, if not his Diſciple, *Hippocrates* made this the Foundation of all his Philoſophy, that congenial things endeavour to approach each other, and diſſimilar fly from each other.

To theſe great Men *Epicurus* is no leſs inferior in Doctrine than Time, who is ſaid to

have

have added to the Principles of *Democritus*, that Atoms are carried thro' a *Vacuum* by the Power of Gravity, the *Inclination* or Declination of the *Atoms*, by which he will have the Conjunctions, Unions, and Adhesions of the Atoms one to another to be effected, whence the World was formed, and all Parts of the World, and all things therein contained. He said that the Atom declined a little from the Line of Gravity, than which nothing is less possible, and this Declination is excellently described by *Lucretius*, *Lib.* 2. *l.* 216.

Illud in his quoque Te rebus cognoscere avemus.
Corpora cum deorsum rectum per inane feruntur,
Ponderibus propriis in certo tempore fermè,
Incertisque locis spatio decedere paulum.
Tantum quod Motum mutatum dicere possis.
Quod nisi Declinare *solerent, omnia deorsum,*
Imbris uti guttæ, caderent per inane profundum:
Nec foret Offensus *natus, nec* Plaga *creata*
Principiis; ita nihil unquam Natura creâsset.
Quare etiam atque etiam paulum *clinare necesse est*
Corpora, nec plus, quam minimum, *ne fingere motus*
Obliquos videamur, & id res vera refutet.

" Now Seeds in downward Motion must de-
" cline,
" Tho' very little, from th' exactest Line:
" For did they still move strait, they needs
" must fall,
" Like Drops of Rain, dissolv'd and scat-
" ter'd all;
" For ever tumbling thro' the mighty Space,
" And never join to make one single Mass.

" If

"If any one believes, the heavier Seed,
"In downright Motions, and from Hin-
"drance freed,
"May ſtrike the lighter; and fit Motions
"make,
"Whence Things may riſe, how great is
"the Miſtake! CREECH.

But *Epicurus* has taken away all that Virtue and Power from matter, after the Formation of the World, which he had aſcribed to the Atoms, whilſt it was forming. For when *Hippocrates* had taught, that the Particles of of Matter approached or retired from each other, by a certain Power not different from that Inclination of the Atoms; *Epicurus* found fault with him, ſo little did he underſtand the Force and Reaſoning of what he borrowed from others, or how far it extended over all Nature, that he objected againſt what was to the ſame Purpoſe, ſo difficult is it for one, who ſpeaks of what he does not ſufficiently underſtand to be conſiſtent with himſelf. Whoſoever he was, that invented the Hypotheſis of Atoms, he certainly well underſtood this Power of Matter, by which the Particles tend towards each other. For this Power exerts itſelf only in the ſmalleſt Particles of Matter, being at Liberty, and free from all others, and diſtant from each other in the very leaſt Degree. Which being perceived the Author of Atoms divided the whole Matter of the World into ſmall and ſolid Bodies, that they might be free to perform all that they could by Nature. Without this Inclination of the Atoms, their Doctrine is quite ridiculous, and has

has been deservedly exploded long ago by many learned Men: but this being granted and applied, we find all Nature agreeing and conspiring to the same End. For this Power of the small Corpuscles is so diffused thro' all Nature, that nothing is performed in the secret Recesses of things, which does not seem to deserve to be ascribed to it. It is therefore very probable, that, when the Antients had found out and perfectly understood this Universal Power and Faculty of Matter, by a diligent Observation of Nature, they came to the same step of Knowledge in terrestrial *Phænomena*, as they had reached in the Motions of Heavenly Bodies.

And hence it is plain, that the Philosophers of all Ages have censured *Epicurus* for that, which best agrees with the Phænomena of Nature, and is confirmed by them; whereas he ought indeed to be censured for neglecting that Force and Power of Matter, to which, with the highest Arrogance and Impiety, he ascribed the Formation of the World But nothing is hard or difficult to a vain Philosopher, who, as things now stand, is not contented to explain, unless he can shew by what Method they could thus be formed from the beginning. But Physicians think it enough for them, to clear some Operations of Nature, which they are obliged to observe with Attention. *Hippocrates* therefore, who is censured by *Epicurus*, was much more modest and more in the right, when he though the Generation and Nutrition both of Plants and Animals, and the Virtues of Plants and Drugs, were to be explained by this Inclination of Matter, or, as he calls it,

Attraction. For he made no doubt to use that every where in his Philosophy, which he had observed to be in all Nature. Nor did he only acknowledge this universal Power of Matter, but also laid it down that some Particles were more strongly attracted by some than by others. In his *fourth* Book of *Diseases*, he explains himself about the Origin of Humours in this manner. Ἐπὴν δὲ φάγῃ ἢ πίῃ ὁ ἄνθρωπος, ἕλκει τὸ σῶμα ἐς ἑωϋτὸ ἐκ τῆς κοιλίης τῆς ἰκμάδος τῆς εἰρημένης· καὶ αἱ πηγαὶ ἕλκουσι διὰ τῶν φλεβῶν ἀπὸ τῆς κοιλίης ἡ ὁμοίη ἰκμὰς τὴν ὁμοίην, καὶ διαδίδωσι τῷ σώματι, ὥσπερ ἐπὶ τῶν φυτῶν ἕλκει ἀπὸ τῆς γῆς ἡ ὁμοίη ἰκμὰς τὴν ὁμοίην. *When a Man has eaten or drank any Thing, the Body draws the said Moisture to itself out of the Belly, and the Springs draw out of the Belly thro' the Veins, each Moisture that which is of the same Nature, and distribute them thro' the Body, as in Plants every Moisture draws that which is of the same Nature out of the Earth.* And in his Book *de Natura Pueri*, he says, Ἡ δὲ σάρξ αὐξομένη ὑπὸ τοῦ πνεύματος ἀρθροῦται, καὶ ἔρχεται ἐν ταύτῃ ἕκαστον ὅμοιον ὡς τὸ ὅμοιον. Τὸ πυκνὸν, ὡς τὸ πυκνόν· Τὸ ἀραιὸν, ὡς τὸ ἀραιόν. Τὸ ὑγρὸν, ὡς τὸ ὑγρόν· καὶ ἕκαστον ἔρχεται εἰς χώρην ἰδίην κατὰ τὸ ξυγγενὲς, ἀφ' οὗ καὶ ἐγένετο. *The Flesh, when it is increased, is distinguished from the Spirit, and therein every like comes to its like, the dense to the dense, the rare to the rare, the moist to the moist, and each comes to its own place, according to Similitude, whence also it is derived.* In the Book *de Natura humana* he teaches, that different purges attract different Humours, and draw them out of the Body, as a Plant draws its proper Nourishment out of the Earth; τὸ γὰρ φάρμακον ὁκόταν

ἐσέλθῃ

ἐσελθῇ ἐς τὸ σῶμα πρῶτον μὲν ἄγει, ὃ ἂν αὐτέῳ κατὰ φύσιν μάλιστα ᾖ, τῶν ἐν τῷ σώματι ἐνεόντων. ἔπειτά δε καὶ τἄλλα, ἕλκει τέ καὶ καθαίρει· ὥσπερ τὰ φυόμενά τε καὶ σπειρόμενα, ὁκόταν εἰς τὴν γῆν ἔλθῃ. ἕλκει ἕκαστον τὸ κατὰ φύσιν ἑωϋτῷ ἐνεὸν ἐν τῇ γῇ. *When a Medicine is taken into the Body, in the first place it draws whatsoever is in the Body of its own Nature; and afterwards draws the rest and purges them. Just as Plants draw that Nourishment, which is suited to their Nature, out of the Earth where they grow, or are sown.* In the *sixth* Section of the *sixth* Book of *Epidemicks* we find this remarkable Sentence; Σάρκες ὁλκὴ, καὶ ἐκ κοιλίης, καὶ ἔξωθεν, δῆλον ἡ αἴσθησις, ὡς ἔκπνοον καὶ ἔισπνοον ὅλον τὸ σῶμα. *The Flesh draws both from the Belly and from without. And the Sense itself shews that the whole Body both inspires and expires.* Which Words *Galen* interprets of the Entrance of the circumambient Air thro' the Pores of the Skin, in his Book *de Usu Pulsuum, cap.* 5. where he says, Ὥσπερ διὰ τῶν εἰς τὸ δέρμα περαινομένων, στομάτων, ἐκκρίνουσι μὲν ἔξω πᾶν ὅσον ἀτμῶδες καὶ καπνῶδες περίττωμα, μεταλαμβάνουσι δὲ εἰς ἑαυτὰς ἐκ τοῦ περιέχοντος ἡμᾶς ἀέρος οὐκ ὀλίγην μοῖραν. καὶ τοῦτ' ἐστί τὸ πρὸς Ἱπποκράτους λεγόμενον, ὡς ἔκπνουν καὶ ἔισπνουν ἐστὶν ὅλον τὸ σῶμα. *By the Mouths* of the Arteries *terminating in the Skin, they separate all that is contained in them like Vapour and Smoke; but they draw in no small part from the Air which encompasses us. And this what we find in Hippocrates, that the whole Body both inspires and expires.* This Interpretation is confirmed by what *Hippocrates* says in his Book of *Aliment*, ἀρχὴ τροφῆς, πνεύματος, ῥῖνες, στόμα, βρόγχος, πνεύμων, καὶ ἡ ἄλλη διαπνοίη. *The chief Food of the Breath*

Breath is the Nostrils, the Mouth, the Lungs, and all other Perspiration. And in the Book *de Natura Pueri*, after he has said that the *Fœtus* has its Breath from the Mother, he says the Passage for the Breath is thro' the Membrane with which it is encompassed *within and without.* This Opinion of *Hippocrates*, of the Entrance of the Air thro' the Skin, was not only received by *Galen*, but so obtained amongst all Physicians afterwards down to the last Century, that I believe it never was called in question by any one; but the Physicians were so blinded by the new, and unexpected Light of the Circulation of the Blood, that, when they could no longer discern between Truth and Falshood, like the Fanaticks in the Reformation of Religion, whilst they endeavoured to wash off the Filth contracted by the Iniquity of Time, they rashly cast away the pure and impure together. But for my part, I do not see how the Passage of the Air thro' the Pores of the Skin is any Contradiction to the Circulation of the Blood; nay both Reason and Experience confirm it no less than the Circulation itself. Whosoever considers the Weight of the circumambient Air, with which our Bodies are continually compressed, will easily grant the Ingress of the Air, not only to the Lungs, but to the other Cavities also of the Body, to be necessary to the Preservation of the Life of Animals. If the Cavities of the Thorax, or of the Abdomen, or of the very Brain, were quite void of Air, how would they be able to sustain so great a Weight of incumbent Air? The Atmosphere presses the Cavity of the Thorax with a Weight of 3672 Pounds, if

if we ſuppoſe the Surface of the Cavity to be no more than a Foot and half. But the Ribs and Bones of the Breaſt being compreſſed with ſo great a Weight muſt neceſſarily give Way, if they were not equally ſupported with internal Air; which is the cauſe that we are not ſenſible of the leaſt Preſſure. It is neceſſary therefore, that all the Cavities of the Body be filled with Air of the ſame Elaſticity with the external Air; but as neither the external nor the internal Air always preſerve the ſame Tenor of Elaſticity; there muſt be an eaſy Acceſs from the one to the other, that they may keep an Equilibrium between them, and the Parts of the Body may not be torn and broken by the Force of the Air. If the Gravity of the external Air be increaſed a Tenth Part, the internal Air not being altered, the Breaſt would be preſſed with a Weight of above 300 Pound, under which ſurely no one could draw his Breath. It is neceſſary therefore that there ſhould always be a Way open for the Air to paſs, not only into the Thorax, but alſo into all the other Cavities of the Body.

This is not only deduced from Reaſon, but is confirmed alſo by Experiments; by which it moſt manifeſtly appears, that the Symptoms of catching Cold do not proceed from an obſtructed Perſpiration, but from the Entrance of the Air thro' the Pores of the Skin, as I ſhewed above. And as the Air has a great deal of Moiſture in it, it muſt neceſſarily carry that with it, and add both to the Bulk and Weight of the Body. *Galen*, in his *Commentaries*, in the Place of the *Epidemicks* already quoted, ſays, *He has heard from ſome, that when they*

they have returned Home from a Journey thro' the ſcorching Sun, and found their Body foul, and their Mouth exceeding dry, and were tormented with a moſt parching Thirſt, upon waſhing, their Thirſt was quenched, their Mouth moiſtened, and their whole Body being rendred ſoft and moiſt loſt the Foulneſs it had contracted. He ſays that *others alſo unqueſtionably perceived their Bodies to attract the Water in the Baths.* That the Air draws all Liquors to itſelf, and receives them into its Interſtices, is manifeſt from this, that there is none that does not copiouſly emit Air in the Pneumatic Engine, and upon being again expoſed to the Air does not imbibe a ſmall Quantity of it again. We are alſo certain from many Experiments, that ſome Liquors not only draw Air, but alſo Water out of it, in a pretty large Quantity. Every Body knows alſo that the Parts not only of Plants, but alſo of Animals, howſoever they are changed by Art and Care, retain for many Years the Force and Power of drawing the Moiſture of the Air to them. And if we ſee plainly there is this Force in ſuch Things, I would fain know why it may not be granted to animated Bodies? There is certainly an *attracting Force*, a common Affection of Matter, inhering in all Particles of every kind, and drawing ſuch Things as agree in any Similitude or Relation towards one another. With this Power breathing Bodies are endued. Does not *Garlick* applied to the Feet give a ſtrong Smell to the Breath of the Mouth? Do not *Cantharides* laid upon the Skin, make way thro' the Blood and Veſſels to the Kidneys? Does

not *Quickſilver* pervade the ſmall Pores of the Body, and penetrate into the inmoſt Receſſes of the Blood and Spirits? And all theſe, without any external impelling Force, ſo ruſh into the Body, that the Perſpiration which flows out ſtrongly on all Sides cannot hinder their being greedily ſucked in. If ſuch ſolid Corpuſcles attracted by the Body enter the Pores of the Skin, and mix with the Blood, why may not the Moiſture of the Air, flowing all round the Skin, enter the ſame Paſſages, which it is continually ſtriking without Intermiſſion, and increaſe the Body in Bulk and Weight? The watery Particles, which are diffuſed into the Air in Form of Vapour, do not produce ſuch ſenſible Effects, as *Cantharides*, or *Garlick*, or *Quickſilver*, to let us know that they are really entred into our Bodies. So much Moiſture alſo is every Day loſt by Perſpiration, that we cannot ever find by weighing how much is gained by Attraction. If the Body has drawn in half a Pound of Moiſture thro' the Pores in any Day when it has perſpired two Pound; we ſhall find by weighing, that only a Pound and half is loſt by Perſpiration, and nothing gained by Attraction. But if the *Perſpiration* could be ſo diminiſhed, and the *Attraction* ſo increaſed that the latter ſhould be more than the former, which appears in the Experiment I have produced, then the attracting Force of Animals will eaſily be perceived. Thoſe Bodies chiefly draw the Moiſture of the Air, which have leaſt Moiſture in themſelves; for there is a certain Meaſure of *Attraction*, and therefore after Bodies are ſaturated with Moiſture,

ſture, they preſently ceaſe to draw any more. If therefore the Body by abſtaining from Food can be reduced to that Weight, that the *attracting Force* be thereby increaſed, and the *Perſpiration* in the ſame Manner diminiſhed, then its *Attraction* will appear; and it will be eaſily found by weighing how much the *attracted Moiſture* exceeds the *Perſpiration.* And by this Method it appears from Experiment, that a young Man attracted *eighteen Ounces* of Moiſture in the ſpace of one Night (1). To the imbibing of which Quantity the preceding faſt, and the waſting of the Body by Labour, and the Moiſture of the Air at that Time, and the having another Perſon in the ſame Bed greatly contributed.

The Air which continually paſſes thro' the Pores of the Body, neceſſarily carries in with it many watery Particles; and many more are attracted by the Heat of the Body, by which one would rather think the Moiſture would be repelled. *Wax*, *Glaſs*, or *Amber*, being heated by Friction, draw light Bodies to them. Alſo if you lay a ſmall Piece of *Lint* on your Finger, and hold it within the Mouth, the inſide of the Mouth will attract it, before it touches, and the more Hot, the ſtronger the Attraction. From theſe Cauſes all the Vapours of the Air are continually attracted and imbibed by our Bodies; but as the daily Perſpiration far exceeds all theſe, it is very hard to know how much is attracted or perſpired. Beſides, as dry

(1) See Tab. 4. *Decemb.*

Bodies attract more than moiſt, and thoſe which are extenuated by Hunger, Labour, Sickneſs, or any large Evacuation draw the Moiſture of the Air more ſtrongly, greedily, and plentifully, that the emptied Veſſels may be filled. Therefore it greatly concerns thoſe whoſe Bodies are waſted by any of theſe, to take Care what Climate and Air they expoſe themſelves to. For as all the Pores of the Skin are like ſo many Mouths, which draw not only the Air, but alſo every Thing that flies in the Air, whether beneficial or injurious to the Blood, the greateſt Care is certainly to be taken by thoſe who are recovering from a Diſeaſe in chooſing their Air, no leſs than in their Courſe of Diet.

Hence alſo it follows, when any Diſeaſe is epidemical, that every Evacuation is bad; for by this Means the Body is rendred more apt and ready to receive and imbibe the Seeds of the Diſtemper.

This Faculty of abſorbing the Moiſture thro' the Skin ſeems to have been perceived by the methodical Phyſicians, who were called *Diatritarii*, for as it was their Practice to begin the Cure of Diſeaſes with Faſting *three* Days, all this while they not only anointed the Bodies of their Patients, and covered them with Cataplaſms and oiled Cloaths, but alſo changed the Air of their Chambers with Fumigations: So careful were they to defend all the Avenues to the Blood, that nothing noxious or unmedicated might enter. Nothing was more in Uſe among the Ancients, than anointing the Body; with this they reſtrained the too great Sweating

ing after Bathing and Exercise; with this they relieved those that were tired with Labour or a Journey; this they thought agreed with Men and Women, sick and well, the Vigour of Youth, and the Decline of old Age; this they used Summer and Winter, Morning and Evening. And what makes most to our Purpose, immoderate Unction is reckoned by *Celsus* amongst those Things which dry the Body; which certainly can be done no other Way than by shutting the Moisture of the Air out of the Blood; for of itself it moistens and relaxes. Unction might certainly be of no small Service to us, who live in a moist and thick Air; but unusual Things are esteemed new, and are not admitted by the Vulgar without Difficulty.

A pure and thin Air has but little Moisture, for it agrees even with emptied Bodies; wherefore we draw less Moisture thro' the Pores of the Skin in the Summer and in the Day-time, than in Winter and in the Night-time. And as we are most obnoxious to the Injuries of the Air when we are asleep, those who sleep uncovered in a cloudy Air run a great Risk of their Lives; for the Moisture being plentifully attracted causes Coughs, Defluxions, and Pains of the Joints.

Nor do only the Vapours of the Clouds and Earth find an easy Passage thro' the Skin, but the different Humours also, which other Animals emit by continual Perspiration, are received by others, by continual Attraction. Hence it comes to pass, that those who live in a City, not only close with Houses, and

abounding

abounding with unſavoury Sewers, but alſo full of People, draw an Air clogged with much excrementitious Matter, and all Sorts of Stenches, by which Means the Blood and the Heart are affected with a continual Heat, which being exagitated by the Temptations of the Town, and the Delights of a voluptuous Life, diſſipates and conſumes the Food of Life by continual Motion. But thoſe who live in the Country, draw a mild thin Air, perfumed with Odours of the moſt fragrant Flowers and ſalubrious Herbs, refreſhing the Spirits, giving a mild temperature to the Blood, and cauſing a chearful Mind and a vigorous Body.

But the Communication of the Bed is no leſs to be conſidered with regard to the Health, than that of the Place where we live; for the Attraction of naked Bodies, lying near one another, under the ſame Bed-cloaths is ſtrong and powerful; they mutually cheriſh and warm each other, and are involved with a warm Steam of Perſpiration as with a Cloud; and as great Part of Life is ſpent in ſuch Communications, it is no wonder if they communicate their Qualities to each other. By this Means the Itch is propagated; by this the Humour ſweated out of a foul Body infects the ſound with the Venereal Diſeaſe; by this warm Youth reſtores old Age; by this the juicy Girl lying with a dry old Man languiſhes and withers.

But to conclude, by what has been ſaid it abundantly appears, that every change of Air may affect our Bodies; and that, as the ſmalleſt Corpuſcles of Nature are endued with the

greateſt

greateſt Power, the more ſubtle the Exhalation from the Earth or heavenly Bodies is, with which the Air is infected, the more grievouſly we ſuffer, and that both *Endemic* and *Epidemic* Diſeaſes may ariſe from inſenſible Cauſes, which neither change the Weight nor Heat of the Air.

FINIS.

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